# POWER

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## Facing New Conditions

THE year just closed has been marked by its economic, rather than its physical developments, so far as concerns the power field. Following the peak of inflation consequent upon a period of reconstruction, the new year finds the spotlight turned upon many cases of profiteering, notably in the coal industry. The pendulum has begun to swing in the opposite direction, and there is a perceptible downward trend in prices, accompanied by a temporary slackening of industry.

This condition has brought relief from abnormal demands for power in certain manufacturing centers and thus affords opportunity for paying attention to needed plant improvements and rational plans to meet future development.

The period just passed through has forced a realization of the fact that our former wasteful ways of doing things must give place to more efficient methods. While conservation of raw materials and heat units has not always been consistent with conservation of capital, the increasing prices of fuel and labor have tended in many instances to reverse these conditions and render power a larger factor in the cost of the manufactured product. Noticeable in this connection is the greater interest being shown by executives in the operating problems of their power plants.

Toward the solution of these problems POWER will direct its efforts during the new year, and it trusts that the continued confidence and co-operation of its hosts of readers will make possible greater service toward this end.

# Review of the Year

## What the Last Year Has Produced in the Power-Plant Field; Tendencies in Design and Practice; and Economic Problems That Must Be Met

## Progress of the Superpower Survey

By W. S. Murray
Chairman, Superpower Committee

W. S. MURRAY

He is a public benefactor who can make two blades of grass grow where one has grown before. He said well who said this, and this principle should be emulated. Mr. Buckland, vice president New York, New Haven & Hartford R.R., said: "He is a public benefactor who can make one ton of coal do the work of two." When he said this, he also made the quotation with regard to the blades of grass, but he did not mean that we should burn less coal but burn it more effectively. Such is the duty and such will be the performance of the Superpower System—to make one ton of coal do the work of two and further, while doing it, do it with one-third the machine capacity now installed in the public-utility plants, on the railroads and in the industries now existing in unassociated relation.

The columns of *Power* have contained other articles that have fully described the great regional power plan typified as the "Superpower System" in application to the territory existing from Boston to Washington and inland 150 miles, and so I shall assume a further description of it unnecessary. Readers will now be more interested in the progress of the work of the Superpower Survey, dealing with the collection and analysis of power data, which will form the foundation upon which to mold and construct the regional plan the performance of which will secure to the people the economies mentioned.

Congress passed an appropriation of $125,000 for this survey and made it effective July 1, 1920. Since that date the Engineering Staff and Advisory Board described in *Power* of Aug. 24, 1920, have been in action.

On Aug. 28, 1920, a full set of information sheets dealing with the amount of power generated and its cost, the coal consumption involved, the growth expected in the next ten years and a number of other important power considerations had been formulated and mailed to 330 public utilities generating power in excess of a demand of 500 kilowatts.

Our records indicate that on Oct. 30, 98 per cent of the information sheets had been acknowledged; on Sept. 4, 3 per cent of the information requested had been received; on Oct. 30, 52 per cent; on Nov. 27, 68 per cent, and now, 93 per cent of the full information required is in our files. It had been expected that we would be able to secure about 85 per cent of this informtion, but these records now indicate that the acknowledging letters meant that public utilities were as much interested in the report as myself, and that within a short period the 98 per cent acknowledgments will be backed by 98 per cent information. So much for the utilities and their splendid response.

As with the utilities, so with the railroads. There are some twenty systems involved in this zone, and the information we have requested is complete from 85 per cent of them; the remaining 15 per cent, carrying the larger mileage, have necessarily taken a longer time, but complete information is indicated in a few weeks.

In reference to the isolated-plant industry, as can be readily understood, a very large and reliable amount of information is secured from the census reports. It will be of interest to know that out of 355 of the industries in this zone, 36 consume 76 per cent of the total coal allocated to them, while only 16 account for 68 per cent coal. The procedure, therefore, with regard to our investigation on the industrial side of the problem is concentration upon these 36 industries securing full

data regarding horsepower and coal consumption from the Census Bureau, whose work in this line fortunately coincides with our own, and the securing of reports from individual experts in these several industries with which to cross-check the findings of this branch of the Engineering Staff.

L. E. Imlay, Chief of Power and Transmission Department, Dr. Cary T. Hutchinson, in charge of the Railway Division, and Henry W. Butler, Chief of the Industries Division, all collaborating with Henry Flood, Engineer-Secretary of the Survey, have this work up to schedule and the time allotted between May 1 and July 1 for the preparation of final report text will be available for that purpose. I look, therefore, with assurance upon being able to make this report a public document upon completion of the Congressional year, July 1, 1921.

### Estimated Energy Requirements

From the amount of data that has been received it would appear that the early estimates of the total power consumption within the zone were not far off the mark, as in 1920 the demand in energy is indicated to be approximately 27,000,000,000 kw.-hr.; in 1925 this grows to 38,000,000,000, and in 1930 to 50,000,000,000, these amounts comprehending the utilization of power in all forms of application. Of these total amounts it would appear that the Superpower System could supply in 1925, 28,000,000,000 kw.-hr. and in 1930, 36,000,000,000 kw.-hr., or approximately 75 per cent of the load would accommodate itself to a co-ordinated electrical supply.

One of the most interesting features in the supply of this energy through a superpower system is in the fact that, notwithstanding the energy demand will have grown from 12,000,000,000 kw.-hr. in 1920 to 36,000,000,000 kw.-hr. in 1930 (three times as much) through the more efficient production of energy by the Superpower System the coal burned in 1930 will be only 14 per cent in excess of that required in 1920.

In earlier calculations I figured that we could have saved 30,000,000 tons of coal had the Superpower System been in service in 1920, and oddly enough our survey data have today practically checked this preliminary estimate.

Looking for a moment at the railroads in detail, out of some 30,000 miles within this territory measured upon a single-track basis, the data so far collected would indicate that there is a sufficient density of traffic upon some 6,000 miles of it to sustain electrification, and though this is only 20 per cent of the total mileage, yet 75 per cent of the total coal burned will be included on these 6,000 miles. The father of electrification is density of traffic, which in turn is split up into three parts—the savings to be effected in fuel, motive-power repairs and the saving in train miles through the consolidation of trains, the last-named offered in the higher "speed-torque" characteristics of the electric versus the steam locomotive.

### Allocation of Load Centers

The power data delivered by the three divisions of the survey are permitting L. E. Imlay, division chief, power and transmission, to allocate rapidly load centers, distribution and transmission lines. On a huge map occupying one wall of his office there are shown, by means of a color scheme, the energy and power requirements, their load centers, also tentative transmission and distribution circuits. Thus in a very short time the power data in full will be assembled upon this map, and in its finality it will present a graphic and geographic representation of the proposed superpower system.

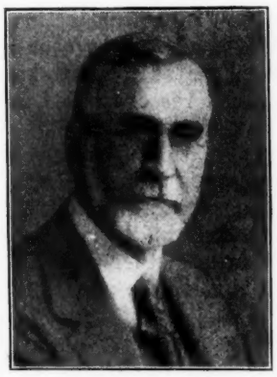
While the engineering staff is busy with its problem, the advisory board is dealing with other phases of the work, its considerations having to do with legal status, finance and intercorporate relations.

As in the case of the transmission of coal in cars across state lines and similarly with oil in pipes, so in the case of the superpower system, as energy will be transmitted over wires across state borders, this will fall under interstate commerce, thus presupposing that the superpower corporation, when organized, should be under a Federal act, but while functioning under such a charter it is not proposed that the superpower system be built with Government funds.

The superpower system will supply power where its costs are less and accept power where the reverse conditions exist, but at every point it will respect the entity and franchise rights of existing utilities. Such regulation as may be imposed upon it must insure to the investors in such a system a full and adequate financial return, and in so doing insure to the people an adequate and reliable power, back of which will stand in 1930 a conservation of some 53,000,000 tons of coal. This will relieve the railroads of this enormous and wasted burden, while the remaining tonnage, required for power and light, converted into electricity and placed on an overhead common-carrier system, will further amplify the new cargo space so created and now so seriously required for other commodities.

# Power for Industrial Plants

By Charles T. Main
Consulting Engineer, Boston, Mass.



CHARLES T. MAIN

As central-power stations, either water or steam, have been developed in a larger, more efficient and a more reliable manner, the tendency to build or install private power plants has decreased, and today the trend is strongly toward the use of purchased electric current for power rather than the installation of a privately owned plant to produce the power in industries where the power requirements are of more importance than the requirements for steam for other purposes and where the private plant does not assume such a size as to be in the class of central-power stations.

This change has come through the changing economic conditions, largely brought about by the World War, although some men were thinking in these terms before that period.

The earlier reasons which favored purchased current for power were that less capital would be required for a new business enterprise, or a greater amount could be expended for production plant with the same capital

available and that less care and attention would be required for power problems.

The more recent reasons favoring purchased current were increasing costs for power-plant construction and the desire to avoid this expense, the increasing cost of fuel and difficulty of procuring it and the desire to eliminate so far as possible the human element in the power department. It is also true that the rates of the central stations in almost all cases did not increase in the ratio of increased cost of production.

As the production of power has been increasingly turned over to the central stations, some of them in turn have found it difficult to meet the demand because of the inability to raise the money needed to increase the plant, and individual plants have been built which otherwise would not have been.

Also, many of the central plants under old contracts have not received sufficient revenue to meet the high cost of fuel, labor and fixed charges in plant and have been going through a period of readjustment.

On the whole the tendency is toward the central-station power rather than individual plants, except in industries that have use for the waste heat of the power plant in the form of low-pressure steam or warm water for manufacturing purposes or process work.

### Central Station Versus Isolated Plant

When the central power station is hydro-electric and has been built at a reasonable cost, it can produce power more cheaply than an isolated steam plant. If the central station is a steam station advantageously situated for receiving its fuel and delivering its electric current, by reason of its large and efficient units it should be able to deliver current more cheaply than it can be made in most isolated plants.

While the central station, whether hydro or steam, is conducive to the conservation of our national resources, we have not reached the time when many men individually are moved to a decision as to what action they should take based on what is good for the country as a whole, but reach their decisions as to what kind of power they will use for financial reasons based largely in the direct return to them, as mentioned previously.

In the future greater consideration should be given to the value of the product, which is usually many times the cost of power, and to the great advantage in having a source of power that is as nearly independent as possible from transportation, labor and other troubles that might interfere with the running of the plant and getting a full production.

The majority of industrial concerns have comparatively little use for steam excepting for power and heating, and in some of these the heating is done chiefly during the hours when the power plant is not in operation, nights and Sundays. For such plants the percentage of byproduct steam that can be made use of throughout the year is so small as to be negligible when considering the purchase of power.

### Power for New Enterprises

In such concerns electric current can generally be purchased at a price not exceeding the cost of producing the power with an individual plant. A new enterprise, under these circumstances, can save the expense of installing a power plant. In a concern already having its own power plant, it is necessary to charge into the cost of power the fixed charges of this plant until such time as it can be abandoned and written off.

In some particular kinds of business, like a woolen mill, dye house, bleachery, soap factory, sugar refinery, etc., there is use for a portion or all of the waste heat from the prime movers in the form of low-pressure steam and warm water. In such industries it is practically impossible for the central power plant to compete.

The modern industrial power plant has become so complicated that the design and arrangement of the steam and electric distribution systems should be made by expert engineers and run by competent operating men, who will give careful consideration to the heat balances between the heat demand for manufacturing purposes and the power demand.

Some concerns have found it economical to produce power from their own power plant only in such quantity as will supply the required byproduct steam or warm water and to purchase from the central station all power in excess of this amount. Others, having large demands for lower-pressure steam, have considered or are actually producing more power than is needed for their own uses and selling the excess to power or other companies.

### Popular Type of Prime Mover

For the private power plant the steam turbo-generator leads in popularity all other types of prime movers. Its popularity is due to the low cost of the unit, small space required, better full-load economy than the steam engine except in the small sizes, more economical steam consumption at fractional loads, and the very important feature of freedom from oil in any steam extracted or condensed from the turbine.

The bleeder, or extraction, type lends itself satisfactorily to plants where a part of the exhaust steam and some or all of the warm water can be used for manufacturing. The non-condensing turbine is applicable where all the exhaust steam can be used.

### Types of Boilers for Industrial Plants

With the advent of electric transmission of power and the consequent concentration of power plants, larger units and higher boiler pressures required, the water-tube boiler has become generally used excepting in the smaller plants where the fire-tube boilers are still in considerable favor.

The use of stokers with the larger units is a necessity, and the modern industrial boiler plant has all the refinements condusive to efficiency.

### Fuel Oil and Powdered Coal

The use of fuel oil in the industrial power plants in New England is a relatively small factor, owing to the inability of the fuel-oil companies to supply this fuel. Prices of fuel oil have increased rapidly. Estimates on its cost in comparison with coal, previous to the recent rise in prices, have shown but slight difference, if any, in favor of this fuel and not enough to be a deciding factor.

The plants that have adopted the use of fuel oil have had under consideration avoidance of labor troubles in the fireroom rather than the saving by its use, or have adopted it with a view of temporarily increasing the capacity of a plant in a limited space.

It seems reasonable to assume that shipping and land transportation should acquire a priority claim on fuel oil over its uses for stationary plants.

Owners have generally come to the conclusion that in any sizable plant the electric drive is the one to adopt,

not necessarily on account of economy, as the cost may be greater, but for its convenience, cleanliness, flexibility, small space occupied and other advantages over mechanical transmission.

Alternating-current motors are by far the most commonly used. Direct current is employed in many cases where variable speed is required. The group drive is still the most common, but there is a distinct tendency toward smaller groups. Motors for individual machines are very common and there is a tendency toward their further use.

### Water Powers in New England

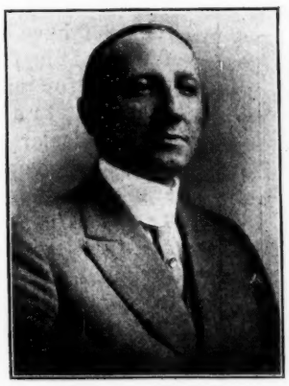
The Federal Water Power Act will probably not affect the further development of water power in New England. Water power is now fairly well developed except in Maine, but there are still some attractive possibilities for new developments and some opportunities of developing what is known as surplus power, which can be used for several months in the year as a coal-saving device, if the price of coal is relatively high, as it now is.

There is a wide field for improvement in existing developments by the replacement of old and inefficient wheels by new, efficient ones placed in more efficient settings. This work is going on to some extent and will probably be hastened when conditions become more satisfactory for carrying on works of improvement.

The Federal Water Power Bill will clear up many of the uncertainties surrounding developments in other parts of the country and will tend to cause greater activity in this line wherever the financial conditions will warrant proceeding with such development work.

# Water-Power Development Outlook

By O. C. Merrill
Executive Secretary, Federal Power Commission



O. C. MERRILL

THE problems of the year just passed have been largely concerned with recovery from the effects of war. Ordinary activities had been suspended and all efforts directed toward military ends. We have had not only to resume our ordinary activities, but to bring up to date those that had been suspended during the progress of hostilities. Power development has not yet recovered lost ground. There has been, however, considerable activity during the year in hydro-electric installation notwithstanding high costs of material and of labor. The largest project has been the reconstruction of the plant of the Hydraulic Power Co. at Niagara Falls. This work started as a war measure due to the shortage of power in the Niagara district, involved the consolidation of the Niagara Falls Power Co., the Cliff Electrical Distributing Co. and the Hydraulic Power Co., an extension to the plant of the last-named and the installation of three units of 37,500 hp. each, or a total of 112,500 hp., described in *Power*, Sept. 14, 1920. Outside of the Niagara district, California has shown the greatest activity. The Kerckhoff plant of the San Joaquin Light and Power Corp. of 40,000 hp. (*Power*, Dec. 14, 1920), and the San Francisquito No. 2 plant of the City of Los Angeles of the same capacity, were completed and put into service. The Great Western Power Co. has under construction a plant of 45,000 hp. on the Feather River, and the Southern California Edison Co. has been hastening construction of its 40,000-hp. plant on the Kern and making extensions to its series of plants on Big Creek. Developments of smaller capacity have been completed or are under way, in Washington, Utah, Wisconsin, Maine and Connecticut. Altogether, probably not less than 400,000 hp. of new water-power installation has been added during the year. Two projects of unusual magnitude which have been under construction are the Wilson dam at Muscle Shoals on the Tennessee and the Chippewa-Queenston development in Ontario. The completion of the latter and the recent purchase of the Toronto Power Co. will place under the control of the Hydro-Electric Commission the largest power system in the world.

### Tendency Toward Large Hydro-electric Units

The year has exhibited a continued tendency toward larger hydraulic units, more extended interconnection and higher transmission voltages. Single units of 40,000 to 50,000 hp. and transmission voltages of 220,000 volts are being proposed. The construction of the connecting link between the central and southern California transmission system has produced the most extended transmission network in existence, reaching from southern Oregon to the Mexican border and backward into central Nevada. Depletion of oil resources and a serious shortage of water during the year have hastened the policy of interconnection in California and have been largely responsible for the considerable increase in water-power development in that state. The successful operation in parallel of steam and hydro plants over so large a territory will undoubtedly lead to further extensions of the California system and to similar interconnections elsewhere, particularly in Washington and Oregon, in Montana, Idaho and Utah, and in the South Atlantic States.

An undertaking that may have an important bearing on water-power development in the Eastern States is the investigation known as the "Superpower Survey," carried on during the year in the northeastern industrial area by the United States Geological Survey. It is expected that plans will be developed from this survey for the utilization of many important water-power sites as a source of energy for the proposed transmission system.

### Water-Power Development in Other Countries

Other countries have been actively engaged during the year in water-power developments or investigations. Sweden is proposing additional plant construction and a system of high-tension transmission to connect its various stations in the southern and central sections; Great Britain has been investigating the possibilities of water-power development in the British Isles and in India; Spain has outlined a plan for a high-tension transmission network covering the entire country, with power supplied from hydro-electric stations; France, Italy and Switzerland are proposing extensive develop-

ments as a means of reducing importation of coal; Japan is making an extensive survey of power possibilities of that country; and even Bolshevik Russia has declared its intention of embarking upon an extensive program of water-power development.

The most important event of the year in its bearing on water-power development in this country has been the passage by Congress of the Federal Water Power Act. This act, after ten years of discussion, has at last established a definite national policy toward water powers. The act of 1901, which governed developments on the public lands and national forests, gave authority to issue only a permit, revocable at the will of the officer who granted it. The act of 1910, which governed developments on the navigable rivers, placed unknown liabilities upon the grantee, and authority could be secured only by a special act of Congress subject to repeal or to such modification as Congress at any time might care to make. While in the twenty years that the act of 1901 remained in effect several hundred thousand horsepower was developed upon the public domain, largely in the nature of extensions to systems already existing outside, only two developments involving a total of 34,500 hp. appear to have been built on the navigable rivers under the provisions of the act of 1910. That water-power development was awaiting adequate Federal legislation and that the new legislation offers terms that a prudent investor is justified in accepting needs no better evidence than the fact that in the six months since its passage 125 applications have been filed, involving more than 10,000,000 hp., of which one-half is on navigable rivers in the Eastern States.

Since this legislation bids fair to mark the beginning of a new era in water-power development, a brief statement of its main features seems desirable. In place of the uncertain tenure and unknown requirements of previous laws, the applicant for a power privilege may secure a "license" for a term not exceeding fifty years. This license is a contract between the Government and the licensee, will expressly contain all the conditions which the licensee must fulfill and, except for breach of conditions, cannot be altered during its term either by the executive or by Congress without the consent of the licensee. If a licensee fails to begin construction under his license, it can be canceled by executive action, but after construction has started, only by judicial action, and then only if no other appropriate legal remedy is available.

### Power Development Agreement

When the license period expires, the United States may take over the properties of the licensee for its own use, permit them to be taken by another or issue a new license to the old licensee. If the properties are taken away, the licensee must be paid his "net investment" in the properties, an amount equal to the actual investment plus severance damages and less such sums in depreciation and amortization reserves as have been accumulated during the period of the license after having received a fair return upon the investment. If the license is renewed, it must be "upon reasonable terms." While "unearned increment" and intangibles will not be recognized, the basis of payment will protect every dollar of actual honest investment in the properties.

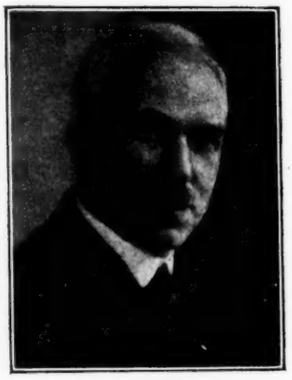
The licensee is required so to plan his project that it will conform to a scheme of development providing for the fullest reasonable utilization of the resources of the stream. He must maintain his plant in good operating condition, make the necessary replacements of worn-out or obsolete equipment, provide out of earnings adequate depreciation reserves for such purpose and maintain a system of accounting in such form as may be prescribed. He must also pay reasonable annual charges for reimbursing the United States for a proper share of the cost of administration of the act and for recompensing it for the use of its land or other property.

The administration of the act is vested in a Federal Power Commission consisting of the Secretaries of War, Interior and Agriculture, who act through an executive secretary, assisted by a technical staff. In addition to the issuance and administration of licenses, the commission is authorized to make investigations of wide scope and is required to make valuation of all constructed projects that are brought under the provisions of the act. The commission has organized, and though hampered by failure of Congress to provide any personnel, it has borrowed individuals from the several departments, and by this means has gotten its work well under way.

While unsettled financial conditions in the period of industrial adjustment through which we are passing may delay water-power development somewhat, the depletion of the oil reserves, the increasing cost of coal and the difficulty in transporting it in the quantities required by modern industry, the advances in recent years in high-tension transmission and in the parallel operation of electric stations through interconnection over wide areas, and finally, the passage of adequate Federal legislation opening up the vast resources under Government control, seem to forecast at an early date a development of our water powers on a scale hitherto unknown.

# Fuel Situation in 1920

By O. P. Hood
Mechanical Engineer, U. S. Bureau of Mines



O. P. HOOD

THE days of 1920 have been filled with fuel troubles for miner, operator, transporter, dealer and user, with a considerable accent on the user. The world has been short of fuel and the United States has felt the shortage. Unusual conditions, an industry functioning poorly, insufficient transportation facilities, speculation and profiteering all combined to make it difficult for the buyer to see his way clearly or do business happily.

The net result of the year seems to be that the miner has raised his standard of living, the operator has made money, and the railroad has somewhat improved a woefully inadequate service. The dealer, in company with a lengthy list of hangers-on, is on the defensive in regard to price, while the buyer receives inferior coal and pays prices never before asked.

Each factor has contributed its share to the turmoil. The people are feeling that everyone along the line has taken advantage of the situation to the detriment of the public welfare. At the same time the public pretty generally forgets its own share of the blame—its old-time satisfaction in too cheap coal, the output of an industry whose human factors were not happy; its lavish and wasteful use of a diminishing asset; its indifference to coal saving, and its refusal to buy coal in the spring when it could be had at a third of what was paid ninety days later.

The public has lost confidence in figures put out by the coal industry. There was plenty of coal, but the individual couldn't buy it! The price at the mine was only a bit above the increasing wages of miners, but there was none to be had for twice the figure quoted! Nobody was charging too much, yet the price was alarming! There was never greater need of discovering facts and publishing them. These conditions have made it easy to reflect the unrest in the mining industry in England, where nationalization has been the program of labor. As a theoretical proposition our own people do not want the Government too deeply involved in the industries, yet when in trouble the first thought seems to be some sort of Government refuge. The industry was told to conduct its business reasonably or the collective body would try its hand. The admonition was to each individual, since the industry cannot combine, and each individual hopes to continue his own money-making way a little longer and trusts that the other fellow will do the righteous and uncomfortable thing first. Meanwhile economic law seems to be asserting itself, and at the end of the year prices are on the decline. The railroad strike in the spring made a real coal shortage; stocks disappeared and buyers who had been holding off began a scramble for coal. Prices rose until midsummer, when an embargo on export coal enabled tardy New Englanders to buy at declining prices.

### Year's Coal Supply Sufficient

The daily output of coal steadily increased from the low point in April to the end of the year, so that the year's supply, while not making up depleted stocks, has on the whole been sufficient. Its distribution, however, has been such as to cause deep anxiety. First one section and then another has feared for its winter comfort and has demanded transportation privileges. Districts most remote were first served, leaving the most anxious nearer the mining districts to be served last. Local supplies in New York and other near-by districts have been seriously low, and only the blessing of a mild, late fall has prevented suffering. Meanwhile the people are learning how dependent is our mode of life on coal and the proper functioning of the industry that supplies it. A Congressional report states that the industry as at present organized is unable to prevent the "deplorable situation" and that it is the duty of the Government to remedy the evil.

Some have thought that fuel oil would help the coal situation. There has been a slight increase in its use near tidewater, but the net result has been insignificant.

In the old days slack coal could be bought in quantity at prices below the cost of production. Of late the difference in price between slack and run-of-mine has grown less and less until now the large user having to pay for run-of-mine coal seriously considers operating his own coal mines as a relief from some of his troubles.

Pulverized coal is finding increased usefulness in special fields, but its use in preference to stoker installations for large steam plants is still in the balance, with interesting developments promised for the near future.

# Powdered Coal for Power-Plant Boilers

By Henry Kreisinger
Research Engineer, Combustion Engineering Corporation
and
John Anderson
Chief Engineer of Power Plants, Milwaukee Elec. Ry. & Lt. Co.

RECENT successful application of powdered coal to steam boilers seems to mark an introduction to a period of transition in the art of burning coal under power-plant boilers. This transition may be similar to that through which the steam prime mover passed during the last fifteen or twenty years. During this period the steam turbine in large power-plant service has supplanted the reciprocating engine, although it is true that there are many more steam engines made and sold today than twenty years ago. It seems probable that within a few years powdered coal in a similar manner will supplant in certain fields the mechanical stoker, while in other classes of service the stoker may extend its service because of its peculiar adaptation, just as the steam engine is holding its own against the steam turbine in its particular field.

HENRY KREISINGER

There are in the United States several plants burning pulverized coal with sufficient success from the viewpoint of over-all efficiency, service and reliability of operation to warrant investigation of the possibilities when new plants are under contemplation. The over-all operating efficiency of a plant using powdered coal is higher than it is with other methods of burning. The gain in economy is due mainly to low heat losses in the chimney gases, an unusually small amount of combustible in the ash and to the fact that no coal is burned during banking hours.

In the chimney gases the heat losses are low because powdered coal can be burned with little excess air and it is easy to maintain the right proportion of coal and air fed into the furnace. The air infiltration into the setting is small because only nominal draft is required. Owing to the low excess of air a relatively small volume of gases needs to be moved through the boiler, and there is no fuel bed to impede the passage of the air to the furnace.

With proper furnace and burner design the combustible carried away with the ash is so small that the loss due to this cause need not exceed one per cent of the

heat in the coal fired. No coal need be burned when the boilers are banked, as usually the fire can be lighted and made effective within less than five minutes.

As the excess of air and the completeness of combustion can be controlled easily, all coals give equally good service and efficiency. The evaporation is directly proportional to the heat value of the coal, so that coal can be bought on the B.t.u. basis. With a well-designed and operated powdered-coal furnace it is possible to remove the ash without hindrance to operation. Comparatively little repair work on the furnace lining should be necessary. It has been said that boilers fired with powdered coal are limited in capacity. The capacity that can be developed efficiently depends entirely upon the size and proportion of the furnace. This is true of all other methods of burning coal, although perhaps this fact is not appreciated generally by power-plant designers. In a properly designed powdered-coal furnace the ordinary bituminous steaming coal can be burned almost completely at rates of combustion up to two pounds of coal per cubic foot of combustion space. It may seem that powdered coal requires large combustion volume, but it should be borne in mind that all the space occupied by the ashpit and air ducts in the stoker installation is available as combustion space in a powdered-coal furnace. It is a fact that stoker furnaces installed in the past have had entirely too little combustion space, but during the last few years the necessity and advantages of large combustion volume has been appreciated by the more progressive stoker manufacturers, and they now demand that boilers be set high above the floor to give large combustion volume over the stokers.

J. ANDERSON

Another objection frequently raised to powdered coal is that a large part of the ash is carried away with the chimney gases and deposited in the neighborhood of the plant. This objection is not nearly so serious as represented. In well-designed plants much of the ash can be deposited at the bottom of the furnace, in the chambers under the rear part of the boiler, in specially provided pockets in the smoke flue and at the base of the stack. Experiments have shown that not over 15 per cent of the ash in the coal need be discharged into the atmosphere with the chimney gases. This quantity compares favorably with that carried away from other types of furnace. From well-designed and well-operated powdered-coal plants the dust is very fine and is carried a long distance. It is brought down only by rain and deposited over large areas in quantities so small that it cannot be observed. It is like fine beach sand and does not smudge.

Another objection usually made against powdered coal is that the cost of preparation is too high and nearly offsets the gain in boiler efficiency. This objection might have been justified in some of the first attempts to burn pulverized coal with poorly designed furnaces and burners. From these experiments conclusions were made that in order to burn powdered coal successfully it was necessary that the coal should contain less than one per cent of moisture and that at least 85 per cent of the coal should pass through a 200-mesh screen. Of course such preparation of coal would be costly. It seems now possible that the cost of pulverizing coal need not be in excess of the cost of supplying air under pressure to forced-draft stokers.

The pulverizing mills will stand considerable improvement and simplification. Much of the energy used in driving these mills is spent in useless work, and it is probable that mills will be developed using two-thirds or even one-half of the power now required to pulverize coal and thus further reduce the cost of preparing the fuel.

It was not until about three years ago that the work of successfully burning pulverized fuel under boilers in plants where the efficient generation of steam was absolutely essential was accomplished. From that time until about five months ago there was nothing radically different in the methods employed. Beginning last August, however, some courageous steps were taken to ascertain to what limits the old order of things could be changed with a view to improving both operating conditions and efficiency. As a result some discoveries have been made and acted upon, and it would appear as if still further developments are imminent, so that the future looks full of possibilities for the improvement of the preparation and of the methods of burning pulverized coal.

# Smoke Abatement

By Osborn Monnett
Consulting Engineer, Chicago, Ill.

OSBORN MONNETT

After several years' setback, due to conditions brought about by the war, smoke abatement is again being taken up by the various cities of the country. One of the things with which they find themselves confronted, especially in the Eastern States, is the rapidly failing supply of natural gas, which has been relied upon in the past for domestic purposes and has been ideal for this service from the viewpoint of smoke abatement. It now becomes necessary in such cities to cast about for some other domestic fuel. As the anthracite supply is not adequate to meet the increased demand, a large increase in the use of bituminous coal for domestic purposes has resulted. This has served to focus attention on the domestic problem to a greater extent than ever before. Smoke ordinances of the country generally exempt residences from any supervision. Unless some substan-

tial progress is made in this department of the work it promises to become one of the leading questions in smoke abatement.

The burning of coal for power purposes is becoming more thoroughly standardized. Having due regard for the rate of combustion, especially with the higher ash coals of the West, has served to fix limitations under which certain combinations of furnaces and boiler settings can be expected to remain smokeless.

Owing to the unsettled situation in the bituminous field there has been shown an eagerness to use the lower grades of anthracite, and this had aided in the development of apparatus for this purpose. Considerable progress has been made also in burning high-volatile coals, both caking and non-caking, by the forced-draft, chain-grate method.

For smaller plants the year has been marked by a larger introduction of gravity-feed furnaces and semi-stokers as distinguished from the plain hand-fired grate. While the latter can be operated successfully it is always desirable to remove as far as possible the human element from furnace operation, and the tendency in this regard has been for the better.

As to the general situation perhaps the most encouraging note is in relation to the activity of the Bureau of Mines, which, through the General Appropriations Bill, is authorized to extend aid to cities interested in smoke abatement. This aid, which can be viewed as simply one angle of the general conservation movement, places the work on a higher plane than has heretofore prevailed.

In line with the thought of conservation, smoke abatement links up with the problem of low-temperature carbonization of fuels and other processes involving the preparation of high-volatile coal. Considerable research work has been done during the past year on this phase of the subject. In the fuel-engineering field there is no more important problem than this, not only from the smoke standpoint but also from the standpoint of conserving our national resources. Prepared fuels from which have been extracted all the oils, tars and other hydrocarbon constituents should come into use in this country more and more extensively as the years progress. It is this linking up of the smoke question with such problems that offers the best hope for the ultimate solution of the smoke nuisance.

The year 1920 has seen the beginning of more scientific methods in connection with smoke abatement, and the future promises considerable encouragement along this line.

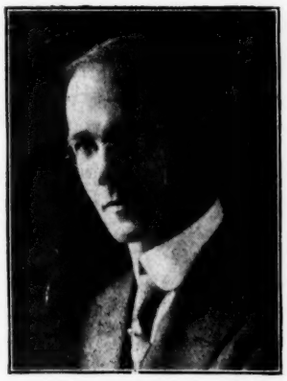
# Steam Turbines

By A. G. Christie
Professor of Mechanical Engineering, Johns Hopkins University

High prices of coal during the last year made the efficiency of central-station prime movers of the greatest importance. The efforts of all turbine manufacturers have therefore been devoted principally to perfecting their respective types and sizes rather than to developing new equipment. Reliability of operation has also been given careful consideration, so that turbines built during the last year have had embodied in their designs many features that will insure longer life and better operation than earlier units. Efficiencies have also been improved, though available test results are too few to warrant any general statement of the gain in per cent. The following turbine performances deserve notice:

A 25,000-kw. General Electric turbine, West End Station, Union G. & E. Co., Cincinnati; 234 lb. gage; 595 deg. F. temperature; 1.145 in. absolute exhaust pressure; steam consumption 10.46 lb. per kw.-hr. at 20,708 kw. load. Efficiency ratio referred to e.hp. 77 per cent.

In England a 1,500-kw. Brush-Ljungström turbine at 1,469 kw. gave these test results: 208 lb. gage; 583 deg. F. temperature; 0.68 lb. absolute exhaust pressure; 12.42 lb. per kw.-hr. Efficiency ratio referred to e.hp. 67.9 per cent. A 1,000-kw. Allis-Chalmers turbine at 1,016-kw. load; 139 lb. gage, 99.4 per cent quality; 2.49 in. absolute exhaust pressure; 16.83 lb. per kw.-hr. Efficiency ratio referred to e.hp. 66.2 per cent. Disk troubles, which became serious in certain types of turbines during the previous year, have been given close study and have been largely overcome by changes in design based on careful research. DeLaval has adopted the built-up diaphragm with formed brass nozzle walls for all its larger turbines and reports improvement in efficiency. The Allis-Chalmers Co. has carried on elaborate research on blading materials to determine which are best for high stresses and temperatures. Careful studies have been made of the ability of various metals to resist fatigue from vibrations. The General Electric Co. has improved blading material and the form of diaphragm walls.



PROF. A. G. CHRISTIE

No units of unusual design or large capacity have been produced during the year, and there have been no appreciably higher steps in operating conditions. However, a considerable number of units of large capacity have been built and many more have been ordered. The largest units to date are the 60,000-kw. Westinghouse three-cylinder sets, while the largest single-rotor turbine is the 45,000-kw. General Electric unit at the Detroit Edison Co. Opinion is divided among engineers regarding the best size of large unit; some favor 30,000-kw. turbines; others those of still larger size. It is not improbable that units of 100,000 kw. will be installed shortly in one of the large power plants, for while there has been a temporary halt in attempts to build large units, developments are under way which will make this larger size possible.

The following new stations of large size were put in operation during the year: The Springdale station of the West Penn Power Co., with 20,000-kw. Westinghouse units; the Delaware station of the Philadelphia Electric with 30,000-kw. General Electric turbines; the West End Plant of the Union Gas and Electric Co., Cincinnati, with 25,000-kw. General Electric units, and the 60,000-kw. Westinghouse units at the Cheswick Power Co., Cheswick, Pa. The following stations are either under construction or being designed: Meadows station

of the Hartford Electric Light Co., with 20,000-kw. units; the Calumet station of the Commonwealth-Edison Co., Chicago, with 35,000- and 30,000-kw. units, and the Hellgate station of New York Edison Co., with 35,000-kw. units. Many other stations have added units ranging from 20,000 kw. to 45,000 kw. to their equipment.

One new feature in power-house economies has been introduced in the designs of some of these stations. This consists of an arrangement of bleeder connections for taking steam from one or more stages of the main turbine near the exhaust end and using this steam to heat the condensate in closed heaters under the partial vacuum of the stages prior to its delivery to the regular feed-water heater or economizer. The gain by this system is due to the fact that the steam is expanded farther through the turbine before being withdrawn for feed heating than if used in the usual non-condensing auxiliaries. This system not only produces a material gain in horsepower developed by the steam, but also an appreciable reduction in the quantity of steam passing through the low-pressure blading to the condenser. It permits either a reduction of about 10 per cent in the area necessary through the last row of blades, or if the standard blade lengths are unchanged, in a corresponding increase in turbine capacity. Auxiliaries in such plants will be largely motor-driven.

The General Electric Co. is still carrying on development work on the Ljungström turbine. The company has also arranged to install at an early date one of its mercury-turbine sets for tryout under commercial service at the Hartford Electric Light Co. This initial set will be watched with interest by all engineers.

Considerable attention has been given to lubrication problems both for turbines and reduction gears. Allis-Chalmers Co. is incorporating a batch-filtration system on all large units.

In England attempts are being made to develop special steam turbines of 1,000 hp. and above for airplane and airship service. The condensers have offered the hardest problem in these designs.

Steam turbines with reduction gears coupled to highly efficient multi-stage centrifugal pumps are becoming favorites for municipal water-pumping stations. A 1,225-hp. pumping set in Baltimore on official test gave satisfactory performance. Larger turbo-pumping sets are being built for Philadelphia by DeLaval.

Three 1,500-kw. geared direct-current turbo-generator sets have been installed by the Detroit Edison Co. to drive house auxiliaries. These units exhaust into a barometric condenser which uses the condensate of the main turbines as cooling water and on which the pressure can vary from 5 lb. gage to 24 in. vacuum. A better heat balance and better auxiliary control are claimed for this direct-current system.

Steam turbines still continue to be installed in marine service both for geared and for electric drive. No radical changes in design have occurred during the past year, although the fixed-frame type of reduction gear is gaining favor. Considerable progress has been made in gear design and construction, as it has become more apparent that absolute accuracy in tooth-cutting will eliminate many of the earlier troubles.

The year 1920 therefore has not been marked by any sensational development in construction, but will be remembered as one of marked progress in the improvement of the details and in the efficiency of all prevailing types.

# Boilers and Economizers

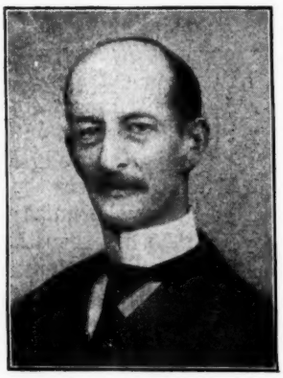
By Dr. D. S. Jacobus
Advisory Engineer, Babcock & Wilcox Company

During the year 1920 the trend in boiler design has been toward the use of a greater number of tubes in height for a given class of work. Adding to the height of the boiler adds to its efficiency with a relatively small increase in draft resistance. By adding to the height of a boiler, leaving the lower part of it and the stoker and furnace the same, the efficiency is materially increased for a given amount of steam produced, the curve of efficiency at different ratings being both raised and flattened. Among large boilers recently installed are some which evaporate in the neighborhood of 150,000 lb. of water per hour under actual conditions, this size being a convenient one to use in connection with the largest steam turbines.

The number of boilers must be such that the plant will not be crippled on shutting down for cleaning or through the accidental shutting down of one or more of the boilers that are in operation, and so far there does not seem to have been a demand for units having a larger capacity than about 150,000 lb. per hour.

Boiler pressures are also being gradually increased, a number of installations having been installed in which the working pressure is 350 lb. with a superheat of from 200 to 225 deg., and with some changes in design there seems to be no reason why higher pressures are not perfectly feasible; in fact, test boilers have been built for 500 lb. pressure and over.

In the larger power stations and in many of the smaller plants a considerably higher class of attention is being given to the operation, and installations that only a few years ago would have been considered entirely too complicated are being used with great success, and through using the more complicated installations material increases in efficiency have been secured. There is no question that better boiler-room operation is essential in many instances if improved results are to be secured in central-station practice. There has been too great a tendency to place the most highly paid engineers in charge of the generating room, and the ambition of a good engineer in the boiler room has been to graduate to the generating room. This condition should be absolutely reversed, and the best-paid and most highly trained man should be in the boiler room. The chances for trouble, as well as for effective savings in the generating room, in these days of automatic devices, are practically nil as compared to the boiler room, and the proper operation and proper upkeep of the boiler room offer tremendous returns and savings, the magnitude of which relatively few appreciate. The savings will be in the first cost as well as in the operating costs, as with com-



DR. D. S. JACOBUS

petent operation a smaller plant can be used for a given output; or, putting it another way, a larger capacity can be obtained from a given plant.

There has recently been a tendency toward higher efficiency in the burning of blast-furnace gas, which was formerly regarded as a waste product. Formerly, the average efficiency was not more than about 50 per cent, while in recent installations boilers twenty-four tubes high with three passes and provided with large furnace volume so that the gas can be burned within the furnace chamber, have been installed. Induced-draft fans are employed to overcome the draft resistance through the boiler and force-draft fans for mingling air with gas at the burners. The same operating crews that handled the old equipment have been trained to operate the more complicated boilers. These modern units, operating at about their rated capacity, are showing efficiencies around 78 per cent, and when operated at 200 per cent of their normal rating, about 73 per cent.

### The Use of Economizers

The question is often raised as to whether it will pay to install economizers. Each case must be considered by itself. As the price of fuel increases, naturally the use of economizers will increase. In considering the use of economizers, the additional efficiency secured through adding to the boiler surface by increasing the height of the boiler should be taken into account. If we start with a boiler, say 14 tubes high, adding tubes so as to make the boiler 16, 18 or 20 tubes high will, for a given amount of fuel burned per hour, result in each case in added efficiency. This additional efficiency is secured without a very great increase in the draft loss, as much of the draft loss in boilers comes through the turns that the gases make over the baffles. The higher boilers can in most cases be operated with natural draft up to the desired capacity, whereas should economizers be installed an induced draft is ordinarily required. In some cases the simplification of the plant by using the higher boilers as compared with one having economizers warrants the use of the higher boilers.

To show how misconceptions respecting boiler performances arise, consider the case of a small plant having several boilers, one of which is uneconomical with a low-draft resistance. The flue-gas temperature for this unit will be higher at a given rating than for the others, and the amount of power obtainable from it will be higher than from the others. This would be especially noticeable if the uneconomical boiler were shut down, as there would then be no additional draft through the higher temperature of the gases from the uneconomical boiler. The operating crew would soon find that when the uneconomical boiler was cut out of service, the capacity would fall off more than in cutting off any of the others, and they might come to the conclusion that the most uneconomical boiler was the best one in their plant.

We are now at a point where we should not allow impression to take the place of facts, and we cannot afford to adopt the easiest way if this means an undue loss in economy. As the price of fuel increases, additional capital investment is warranted, and an equipment for securing a higher efficiency usually means more complication and necessitates a higher class of operation than the more simple arrangement. Our best-run plants are already on a par with laboratories in the care with which they are operated and the skill and ability of those in charge. There are still, however, many plants where the fuel consumption is 50 to 100 per cent higher than it might be. Each time a wasteful plant is replaced by an economical one, we save fuel for future generations and practice real conservation.

## Condensing Equipment

By George A. Orrok
Consulting Engineer, New York City

THE year 1920 in the condensing equipment business has been a year of stabilization and improvement in details in contradistinction to the marked steps of progress which took place in former years. In many cases the detailed development has been carried to a much higher degree and the efficiencies have been greatly improved. The general tendency during the last year has been toward larger units, and many condensers with between 30,000 and 60,000 sq.ft. of surface have been built or projected. There has also been a tendency toward standardization, particularly in the smaller sizes, and while no definite heat-transfer standards have been adopted by the manufacturers, the designs show that this subject is being considered and that the variations are becoming of less moment. There have been few freak designs and much more attention is being paid to shell design and the prevention of air leakage. The design and manufacture of auxiliaries has been improved both in efficiencies and in mechanical details, all tending toward better condensing performance.

GEO. A. ORROK

Tube manufacturers are breaking away from the "quantity production" methods imposed by war conditions, and the coming year will probably show a considerable improvement in this line of manufacture. The adoption of the electric melting furnaces instead of the old crucible method and "rule of thumb" melting has greatly improved tube material. There are also to be reported minor improvements in heat treatment and the metallography of the various tube mixtures.

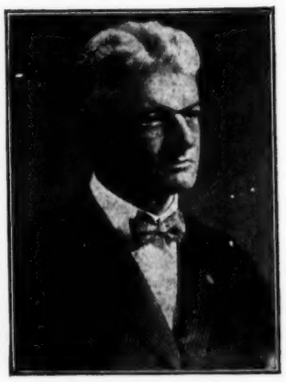
Experimentation along condenser lines is being pursued by both manufacturers and users, although no important research has been completed during the past year.

## Mechanical Stokers

By R. Sanford Riley
President of Stoker Manufacturers Association

THE year 1920 has seen the greatest strides yet taken, not in radical changes of methods and machines, but in the general adoption of highly standardized stoking machines. Big power-plant engineers do not stop to consider whether they will use hand or mechanical firing, but ask at once, "which machine?"

There is an association of stoker manufacturers whose aim it is to still further develop and standardize the various methods of mechanical firing. This industry is highly specialized, run by experts, and is now on a high plane, from both scientific and ethical points of view. During the great war the members of this association received the highest priority ratings for their products, so great was the national appreciation of their ability to conserve labor and fuel. Competition is keen among the exponents of various methods of combustion; both manufacturers and customers now realize more than ever before the value of stability and service. So we now see the erstwhile crude art of making fires recognized as one of our fundamental industries. The highest grade of college-trained men are found in charge of great batteries of boilers. More attention is paid to $CO_2$ and other indications of fireroom efficiency than was ever paid to indicator diagrams and other engine-room refinements of the past generation. The $CO_2$ recorder, steam-flow meter, draft gage and pyrometer are found by the side of the steam gage; and we may be on the eve of still greater refinements along this line.



J. SANFORD RILEY

The great increase in available fuel oil just after the war caused some temporary changing over to that ideal fuel, but economic laws seem to point toward sharp limits on the use of oil, so we may expect a still more general use of coal, even in the oil regions.

We welcome the approaching development of water power as a further recognition of the need of saving coal. Stand-by and auxiliary steam plants will open up opportunities for many more high-class plants than will be shut down by the substitutions of "white coal."

During 1920 there was an increased appreciation of the importance of the combustion chamber; sizes that look like the "inside of a church" have now become standard. The venerable bridge wall has been shoved back and even discarded except as a support for baffles. Doors have been provided for accessibility and inspection all around the furnace. Refractory linings have been built with scientific regard for the strains of high temperatures until it is difficult now to find the weakest link in the chain. When brickwork troubles do occur, they are less serious because of the attention paid to ease of replacement without disturbing other parts.

Ashpits have generally been enlarged correspondingly, and greater convenience of emptying them has been secured by improved door operation. The use of water for quenching has been developed so that in some cases the ashes are actually discharged into water pits, thus eliminating that source of danger to stoker dumping gear.

The big multiple inclined retort stokers apparently command the lion's share of business from big boilers owing to their great overload and peak-load capacity. The maximum size of single stokers has reached 18 retorts, calling for a furnace width of nearly 29 ft. The length of retorts has also been increased, and the end is not yet. The use of rotary clinker grinders in combination with these big stokers is favored by some engineers, though the increase in clinker content tends toward their abuse and danger of breakdowns.

The drives have been further improved and protected. One notable instance is the elimination of chains to individual gear boxes by carrying a continuous drive shaft through a whole series of gear boxes. The use of multiple speed for individual gear boxes is also an accomplished standard equipment.

The single-retort underfeed stokers are doing well in their field without any radical changes. Their ability to fit into shallow settings has made possible great improvements in many old or otherwise restricted installations. Steam-driven rams still prevail, though there has been some development of gear-reduction drives for such stokers. The use of wide overfeed grates in combination with single retorts was especially popular in 1920, and this type of stoker has now had a wide use in new plants. The single-retort underfeeds, including the screw feeds, have had a greatly increased use in metallurgical work and there are more possibilities ahead in this line.

### Chain-Grate Type Stokers

The chain and traveling grates have developed greatly in the direction of forced draft, besides other minor refinements. The subdivision of spaces under the working grate has opened out new possibilities for graduated forced draft and increased capacity. The increased use of anthracite screenings, lignite, coke braize and low-grade semi-bituminous coals has especially encouraged this development of the chain-grate type of stoker.

The brickwork problems of this type of stoker have received special attention, and their various forms of arches are approaching standard practice. While there seems to be a practical limit to the unit width of chain- or travel-grate stokers, there seems to be no such limit in length. This is taken advantage of for high capacities with the poorer fuels referred to.

One novel development is a combination of strips of chain grates in parallel with fixed tuyeres. The commercial record of this progressive device will be watched with great interest.

### Overfeed Stokers

The old reliable V- type, side-feed stoker continues to get a lot of business without any radical modifications. The grates have been improved and developed to suit the power fuels. This type of stoker seems to be more particularly suited to smaller units, as it is self-contained and embodies a complete furnace structure. The use of suspended flat arches rather than self-supported arches seems to be growing in favor, on account of both maintenance and greater combustion-chamber space made available.

The front-feed, overfeed stokers are still selling, but in a more restricted field.

Nearly all types have been modified and exploited to burn fuels that were formerly not considered commercially worth while. The continual increase in waste material in the coal constitutes one of the big problems for manufacturers of mechanical firing apparatus. Probably we shall never again see the high-class coals used as they were—the mines have given up their best

and now one must use poor grades. But improvements in ash disposal seem to keep pace with the needs, so that the modern stoker is well up to its job when properly handled.

The increase in interest and skill in boiler-room operation is gratifying to the stoker industry and is a constant incentive toward better apparatus. The use of pulverized fuel is perhaps the best test of the development of the art up to date. After a generation of effort there are now a few plants burning pulverized coal with such success that a new vision is opened up. The research and careful operation that will make such plants a commercial success will also advance the whole art of mechanical firing. The need of making apparatus foolproof rather than efficient is already less urgent, and we may expect a continued rapid increase in improved means for conserving coal. The exceptionally well equipped plants of today will be the standards of tomorrow.

# Adoption and Promulgation of A.S.M.E. Boiler Code

BY CHARLES E. GORTON
Chairman, Administrative Council American Uniform Boiler-Law Society

THE scope of the American Uniform Boiler-Law Society's work during 1920 has been broadened somewhat. When the society was organized it was for one purpose—the promulgation of the A. S. M. E. Boiler Code and its legal adoption by the several states of the Union; but since that time we have tried to make the office of the society a clearing house to be used by the members of not only this society but sister organizations and others for the dissemination of information or news that would be of benefit to the members and others.

It was found that the Code was being used in different universities and colleges as a textbook, and an investigation has shown that there are eleven colleges and universities using it as a textbook and nine as a reference book. Thus it is readily seen that the Code has even a larger sphere of influence than was originally thought. Not only the states that are coming in and adopting the Code as their boiler standard but the universities themselves are using it as a textbook, so that young men in their engineering courses are thoroughly grounded in the Code.

One matter that came before the society during the year was the advisability of organizing an association or board that would bring about three things: First, the uniform stamping of boilers; second, the uniform examination of inspectors; and third, uniform interpretation as applied to the states that already have adopted, or those that will adopt, the Code. On Dec. 2, 1919, during the annual meeting of the A. S. M. E., the society, through its Executive Committee, was instrumental in organizing the National Board of Boiler and Pressure Vessel Inspectors.

The "National Board" was organized for the purpose of promoting uniform boiler laws throughout the jurisdiction of the members of the organization; for the interchange of opinions, rulings, and the approval of specific designs and appurtenances, and devices used in connection with boilers and other pressure vessels; the uniform stamping of boilers and the uniform examination of boiler inspectors, with the object of maintaining uniformity throughout such jurisdictions. The membership is restricted to inspectors or other officials charged with the enforcement of rules and regulations covering boilers and pressure vessels in the states and municipalities that have adopted the A. S. M. E.'s Boiler Code.

With regard to the legislative work of the society, 1920 was what might be termed an off year in legislation. There were only five legislatures that convened during the year, other than those that have already adopted the Code.

In Indiana the question of accepting A. S. M. E. boilers was taken up with the State Board. Under a ruling of the board in 1915 it was agreed to accept Code boilers, but there were certain restrictions placed upon the boilers that practically prevented uniformity. In November, 1919, the question was again taken up with the Industrial Commission and the Chief Inspector, with the result that on the third day of January, the following communication was received:

> We are pleased to inform you that we have the consent of the Industrial Board to cancel the rules of the letter written Dec. 17, 1915, to Thomas E. Durban, chairman of the American Uniform Boiler Law Society, of Erie, Pa. The board has agreed to accept the A. S. M. E. Code on the construction of boilers. Boilers must be built in strict accordance with the A. S. M. E. Code rules to be accepted in the State of Indiana. The installation of boilers will come under the Indiana rulings in Section 11, and fusible plugs will be applied as required in Section 13.

As a result of the society's assistance in satisfactorily adjusting, in California, misunderstandings between state officials and two large boiler companies with regard to specifications required for boilers during the war period, we were notified by these boiler manufacturers of a special session of the Legislature that had been called by Governor Olcott of the State of Oregon, to consider emergency measures, and they thought it advisable for us to be present in order that a boiler-law bill might be framed and introduced. Had we not gone to California and helped them out of that trouble, we would undoubtedly have had two of the largest boiler manufacturers on the Coast opposed to our legislation in both Oregon and Washington.

The bill introduced in Oregon was not what would be termed a strictly Code measure. It was drawn to give additional powers to the Industrial Accident Commission. This commission went on record by saying that should the bill pass they would first adopt the Boiler Code of the A. S. M. E., and all other codes which they adopted would be codes of national reputation. It was due in a large measure to the statement which they made at the time that it was possible to get the bill through the Oregon Legislature and have it signed by the Governor.

On March 1 Arkansas adopted the Code and put it in full force and effect, and good progress is being made toward its adoption in Virginia.

The bill that was introduced in the Maryland House called for boiler inspection not only in the City and County of Baltimore but throughout the state. The bill was passed by the House and Senate and has been signed by Governor Ritchie. Its provisions went into effect on the first day of June. It provides for the adoption of the A. S. M. E. Code as the Maryland boiler standard, and the provisions of the Code will be operative on the first day of January, 1921.

The State of Utah reports the writing of boiler rules which would include the A. S. M. E. Code.

There is every reason to believe that the State of Washington will adopt the Code within the next few months. The Code was made a part of the new charter of the City of Seattle, which was voted on by the people March 1, and on March 15 it became effective in that city.

The following states and cities have adopted or accepted the A. S. M. E. Code as their boiler standard:

*States:* Rhode Island, New York, New Jersey, Pennsylvania, Missouri, Delaware, Maryland, Michigan, Ohio, Indiana, Wisconsin, Minnesota, California, Oregon, Utah, Oklahoma, Arkansas.

*Cities:* Detroit, Mich.; Erie, Pa.; Kansas City, Mo.; St. Louis, Mo.; St. Joseph, Mo.; Philadelphia, Pa.; Nashville, Tenn.; Chicago, Ill. (will accept); Scranton, Pa.; Memphis, Tenn. (will accept); Seattle, Wash.

Allegheny County, Pa., has also adopted the Code. The Code has been adopted by seventeen states, of which Indiana as a full Code State, and Oregon, Utah, Arkansas and Maryland have been added this year. The cities number eleven, of which Scranton and Seattle have been added this year.

# The Steam Engine

By B. V. Nordberg
President, Nordberg Manufacturing Company

B. V. NORDBERG

RELATIVE to the status of the steam engine and the direction in which we may look for advancement in time to come, it is the writer's opinion that the increased cost of fuel will compel builders of engines to make improvements in the present designs and in fact to adopt new types. For years European engine builders have been far ahead in the art of building steam engines, and no doubt it will be necessary for us to follow in their footsteps, adopting the same designs that they have developed, in order to be able to run our engines successfully on high-pressure steam highly superheated. This will make it necessary to give more attention to steam-generating plants, the boiler and the superheaters and the purification of the feed water.

Among the greatest improvements that have been made for years in the steam engine is the cylinder design of Van den Kerchove, of Ghent, Belgium. Attention is called to the complete analysis of the results obtained with this type of engine by Schroeter and Kork, published in 1903. It is the writer's belief that this type, with its clearance spaces reduced to a minimum and swept by steam at high velocity, will come into general use.

The Unaflow, or, as it is called in England, the terminal-exhaust engine, lately has become quite popular. Its unquestionable economy is due to the fact that the greatest part of the moisture in the expanded steam is got rid of at the end of the working stroke and before compression begins, and to the fact that by means of the terminal-exhaust slots and the action of the piston as an enormously large valve, almost full vacuum can be realized, so that the back pressure on a condensing engine is reduced to a minimum. This makes it possible to compress to boiler pressure, with a small amount of work expended during compression. This feature is not given the weight it deserves by engineers and designers generally, and still herein lies the most important point of advantage of a Unaflow engine when operating condensing. It is questionable whether any Unaflow engine has material advantage over a well-designed counterflow engine of the Van den Kerchove type. The Unaflow engine, however, has become the "style" at present and no doubt will have its run for some time to come.

It would seem that the Corliss engine has been outclassed by other types designed abroad, such as engines with equilibrium poppet valves. Still the Corliss type of cylinder and valves possesses many advantages that cannot be obtained with any cylinder equipped with poppet valves. In a properly designed engine the clearance volume and the surfaces exposed to the cooling action during expansion can be minimized. Corliss engines are today competing successfully with poppet-valve engines in France and Belgium. Since the time of George H. Corliss some questionable "improvements" have been made in the engine he invented. Mention will be made only of the T-headed valve stem now used by all builders of Corliss engines. By using such a stem only one single gearing is required in the bonnet, with an overhanging driving arm. European Corliss engine builders use a stem passing through the valve with bearings in the bonnet front and back. The Corliss engine in this country has been cheapened by competition without any regard for its economy in operation.

For moderate powers, at least up to 1,500 hp., it is the writer's belief that the reciprocating steam engine, if properly designed, will in time, for certain kinds of service, supersede the steam turbine, owing to the increased price of fuel and the superior economy obtainable with a good steam engine.

# The Unaflow Engine

By W. C. Brown
Chief Engineer, Stumpf Unaflow Engine Company, Inc.

THE last year was the most prosperous for the Unaflow engine in America. Not only were more installed this year than any previous year, but more new types were developed.

Previous to 1920 Unaflow engines in this country were practically all driving electric generators or in other service requiring constant-speed governing. This year variable-speed engines for various services have made their appearance. The first of these new types to be developed was a pumping engine consisting of a single Unaflow steam cylinder connected to a single double-acting water cylinder, also two units similar to the foregoing type on one shaft with ninety-degree cranks. Moreover, Unaflow pumping engines are all operating at higher speeds than usual. Instead of a piston speed of approximately 200 ft. per min., which has previously been employed in pumping engines with voluntary water valves, the Unaflow pumping engines have been run as

high as 700 ft. per min., which has set a standard away above anything done in the past even with positively operated water valves. This high-speed development was not the result of adapting the Unaflow steam cylinder to pumping engines, but happened to be coincident with it.

Unaflow steam engines have been used for some time to drive ammonia compressors from a separate crank, but Unaflow air compressors and direct-connected ammonia compressers have been put on the market this past year.

A novel installation of Unaflow engines this year consists of six engines operating in pairs driving exhausters and controlled by a vacuum in the suction pipe of the exhauster. Even more novel is the marine engine, as this is the first reversing engine attempted in this country, and the valve motion is different from any of the European reversing engines.

An entirely new valve motion—not new in itself, but new in its application to Unaflow engines—has been developed for use with the variable-speed engines. It consists of a long revolving cam straight on the face but tapering on the back. The cutoff is varied by sliding the camshaft endways.

The marine-engine valve motion is similar excepting that as fine variations in cutoff are not necessary in marine practice, the cams are in steps, and there are backing cams on the same shaft.

The Unaflow engines here referred to are of the modern type with heated cylinder heads. All of the installations are operating successfully.

# High-Speed Turbo-Blowers

By Charles H. Smoot
Engineer and Vice President Rateau Battu Smoot Co.

TURBO-BLOWERS are perhaps the newest and most novel type of power apparatus that has come into extensive use. The machines are being rapidly developed, and year by year a marked change is perceptible in their status. The rapidity of the turbo-blower's evolution is due in part to the development of engineering work in design, but even more to the extension of its field of use to different industries.

The commercial application of the turbo-blower in steel works for blowing blast furnaces and bessemer converters is already well established, and the natural objection of engineers engaged in this class of work to new machinery differing radically from older forms is now almost entirely overcome. Today the majority of steel-works engineers—especially those having to do with construction—are giving attention to the use of turbo-blowers rather than the heavier and more expensive reciprocating machines.

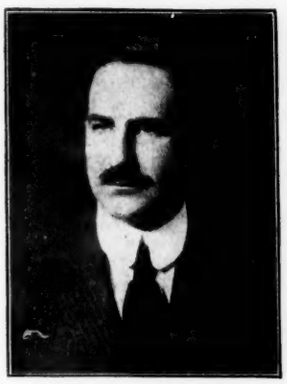
The copper-smelting industry reached this condition some years ago, and the construction engineers for some time past have gone to turbo-blowers, to the practical exclusion of other types of blowing apparatus.

Metallurgy was the first field for the turbo-blower and has opened the way to a large number of important industries, including byproduct coke ovens, gas distribution, water-gas generators, chemical works and all the industries in which compressed air is used extensively for power.

The relatively high-speed blower with direct-connected turbine and helicoidal fan is also coming into favor for large volumes of low-pressure air, such as in the operation of steam-boiler stokers.

In general, the turbo-blower has the same advantage over the older and more slow-speed forms of blowing apparatus that the turbo-generator has over the reciprocating-engine generator. The difference is more marked as the size of the machines increases, but the turbo-blower at any pressure can be made a much smaller machine, of lighter weight, occupying less floor space and requiring less attention, oil and maintenance than the heavier and slower-speed apparatus.

Development of the blowing end of the machine has been toward extreme simplicity of construction, favoring high speeds. At the present time a blower can be constructed with a normal factor of safety, requiring more power at a given speed than can be generated in the ordinary steam turbine suitable for alternator drive, and a new form of turbine construction is coming into use in which the wheels and shaft are machined from an integral forging, permitting a higher rotative speed for a given power than was formerly possible.



CHARLES H. SMOOT

Turbines of several thousand horsepower can be run at speeds of 10,000 r.p.m., maintaining a critical speed of shaft well above that of rotation, as well as normal working stress. This type of turbine, made useful by the turbo-blower, will without doubt lead to important development in turbo-generators.

A very interesting possibility is presented and is at present being considered with reference to 100-lb. compressors, which comprise three or four single-stage turbo-blowers of different diameters running at different speeds, but maintaining practically constant peripheral velocities and normal working stresses, which are driven by steam turbines of corresponding dimensions, the air passing from the large low-pressure blower in series to the small high-pressure blower, the steam taking a reverse path in series through the turbines. At the high-pressure end, where the volumes of steam and air are small, the size of the machine is correspondingly small and the speed high. At the low-pressure end the volumes of steam and air are large, the machine is large and the speed of rotation reduced. This combination is readily possible with a turbo-blower and leads to a maximum possible efficiency on the steam end which is obtainable only by maintaining approximately fixed speeds for turbine buckets, but with changes in diameter of turbine wheel, casing, etc., which are in proportion to the volume of steam passing through.

An additional problem, which has been a handicap to the turbo-blower—that of regulation—has also been effectively solved, and it has been shown that a turbo-blower can be regulated to give a more constant volume of air than is obtainable from a reciprocating machine.

In the case of the blower the volume of air controls the speed of the turbine in such a way that the speed

gives the volume desired. A reciprocating machine is not susceptible of direct air-volume control, owing to its pulsations, and can be regulated for volume only through the speed of rotation. It has been shown that a reciprocating machine at constant speed does not give a constant volume when changes in pressure occur, probably due to leakage, clearances, etc. This feature is of vital importance in metallurgical blowers, where a fixed rate of combustion is desired, as in a blast furnace.

In almost all cases where blowers are required, from the lowest to the highest pressures—a fraction of a pound to a hundred pounds—there is always a problem of regulation, as pressure, volume or some other feature indirectly dependent upon either pressure or volume. These problems have been studied and the necessary apparatus developed. The coming year should see many important industrial problems solved through the application of regulating apparatus and turbo-blowers.

# Electrical Power Industry for 1920 in Retrospect

By F. A. Annett
Associate Editor, *Power*

F. A. ANNETT

In looking back over the last year little is to be recorded of the electrical industry that would make 1920 stand out in a spectacular way over other years. Where previously, for a considerable period, each succeeding year there was recorded an increased size in electrical-power generating and motor units, no such record will remain as a milestone of electrical progress for 1920. However, this does not mean that the industry has been at a standstill or gone backward. Although nothing unusual occurred in electrical power-equipment development, new methods and new apparatus brought out for applying electrical power show that considerable progress has been made toward a more general use of electricity.

At the beginning of 1920 the demand for electrical apparatus reached an unprecedented height and continued almost throughout the year, and it is probable for this reason more than any other that no greater amount of engineering development has been done.

One of the most gratifying features of the year has been the justification of past electrical-engineering development. Turbo-alternators had for years been increasing in size by leaps and bounds, until single machines of 45,000-kw. rating had been reached. As might be expected in this rapid progress, trouble developed and, on account of the large size of these units, caused, in many cases, unpleasant experiences in power-system operation. Conditions under which many of these machines were constructed and had to be operated during the war contributed to the difficulties. As a result of these experiences the wisdom of concentrating such large power in single units was questioned. However, the causes of the difficulties have been remedied to a large degree and the record of the installations made and orders placed during the past twelve months shows that confidence has been restored in the large high-speed turbo-alternator as a power-generating unit.

One electrical manufacturing company reports installation of turbine-driven machines of 10,000-kw. rating and over, having an aggregate capacity of nearly 800,000 kw., while another company reports receipts of orders during the year for turbo-alternators having a capacity of 25,000 kw. and upward, totaling nearly 5,000,000 kw. These machines range in size up to 60,000 kw., driven by triple-cylinder cross-compound turbines and 45,000 kw. in single-cylinder machines. This justification of the large turbo-alternator is found not only in this country but also abroad. One particularly noticeable instance is the shipment to China and India of units ranging up to 20,000 kw.

In the hydro-electric field the adoption of large units continues. One manufacturing company reports the installation of 270,000 kw. of various types above 3,500-kw. capacity. Two of the most notable installations completed during the year are those of the Niagara Falls Power Co., Niagara Falls, N. Y., and the Kerckhoff plant of the San Joaquin Light & Power Corp., California, respectively, described in Sept. 14 and Dec. 14, 1920, issues of *Power*. In the former, three units aggregating 112,500 hp. operate at a generator efficiency of 98 per cent. The over-all efficiency of this plant is remarkable, since 90 per cent of the total energy in the water is delivered at the busbars. In the Kerckhoff plant three units totaling 45,000 kw. have been put in operation, and the generators under test showed an efficiency of 97.62 per cent and the turbine 90.1 per cent. Therefore little can be expected in improvement in efficiency of hydro-electric generators.

Considerable progress has been made on the Queenston-Chippawa development in Ontario, Canada. Five of the generators have been ordered, each to develop 45,000 kva., the largest hydro-electric units so far attempted, and it is expected that the first machine will go into operation during September, 1921.

### Interconnection of Power Systems

Not only has the year 1920 seen the practice continued of concentrating large capacity into single units, but also considerable progress has been made toward interconnecting generating stations and power systems. The interconnecting of power systems, which during the war was brought about in many cases to meet power shortage emergencies, has proved sound engineering.

One of the most notable electrical-power transactions during the year was the taking over of the Sir William McKenzie power interests in Ontario, Canada, by the Ontario Hydro-Electric Power Commission, which gives the commission control of plants in operation and under construction totaling over 1,000,000 hp. This deal makes the Hydro-Electric Power Commission the largest generating and distribution concern in the world.

The most stupendous of all power-transmission schemes so far proposed is that advocated by W. S. Murray and known as the Superpower System of the Northeast Atlantic Seaboard, discussed by Mr. Murray in this issue.

The practice of interconnecting power systems has not been confined to the central-station industry. Some

of the steel companies have found it advantageous to tie together their power plants at different works within economical transmission distances.

Another advance in transmission voltage has been made, this time in 220,000 volts; seven transformers of 16,667-kva. capacity each are reported under construction for this system. These transformers are single-phase, 12,000- to 220,000-volt units. The installation of a 23,600-kva. 12,000- to 132,000-volt 60-cycle transformer marks the completion of the largest unit of this type ever built.

The use of large power units has extended outside the central-station industry. One steel plant has installed a 20,000-kva. turbo-alternator and another a transformer bank consisting of three 8,000-kva. transformers on a total of 24,000 kva. Motor equipments have been installed having a maximum rating of 22,000 hp.

If there is one thought that the people of the world have in mind more than any other as they enter upon a new year, it is that an adequate supply of cheap power is absolutely essential to future development. England with her coal mines is planning superpower systems and the development of her limited water power. Spain has a project under way for a national network of transmission lines connecting hydro-electric and steam stations. France is also making extensive preparations for power development both from coal and waterfalls. The 300,000-kw. superpower station proposed for the City of Paris is an example of what the tendencies are. All European nations that have an abundance of water power are planning a fuller utilization of these resources. Holland, without either coal or water-power resources, is planning a national power system. Nations devastated by the war which today lack sufficient funds to purchase food and clothing are making large appropriations to investigate and develop their power resources. Therefore, although nothing spectacular occurred in 1920 to make that period stand out in power-engineering achievement, are we not justified in looking into the future with high hopes?

# Oil Engines

By L. H. Morrison
Associate Editor, *Power*

THE year 1920 witnessed a more extensive application of the oil engine and a greater number of manufacturers engaged in this work than any previous year. In the matter of design the year's progress has been of interest. A number of new oil-engine designs, both two- and four-stroke-cycle, have been announced to the engineering public.

Since the Diesel is peculiarly adaptable to marine installations both because of space saving and high engine economy, much attention has been paid to this phase of Diesel engineering. Although the number of marine Diesels contracted for during the year falls far below the number of stationary Diesels, more effort, both engineering and sales, was given to the former. This has resulted in increased marine-engine capacities both in two-stroke and four-stroke-cycle units. In distinct contradiction to the prevailing belief in some quarters that the two-stroke-cycle engine is not suitable for ocean-going vessels, one manufacturer successfully constructed and is operating a 2,700-hp. two-stroke-cycle Diesel of purely American design. The last year also witnessed the construction of the largest American four-stroke-cycle marine Diesel, this engine having a normal full-load capacity of 2,400 indicated horsepower.

Since the oil engine possesses certain advantages over the steam turbine or the reciprocating steam engine it is somewhat surprising that more marine Diesels have not been ordered. Several factors contribute to make the progress somewhat slow. The total number of vessels under American registry is not great, being around 2,600. A large percentage of these are Shipping Board vessels not particularly suited for Diesel drive. No great number of vessels already in service will be fitted with Diesels, owing to the cost of this replacement. The marine Diesel will undoubtedly be used in a fair percentage of new ships; however, the number of ships that can be expected to be constructed per year will not be large for the reason that the present ocean tonnage practically fulfills current demands. In the stationary-engine field the Diesel demand during the last year has far surpassed the marine demand. The number of stationary Diesels ordered was several times the number of marine Diesels. The actual number of stationary engines sold by all firms total 144. The greatest applications have been in the oil-pipe lines, small central stations and mines. Other industries, such as irrigation, chemical works, ice plants, etc., have absorbed a considerable volume.

L. H. MORRISON

No radical departures in stationary Diesel design are on record. There is a well-marked tendency toward the extension of capacity ranges; several manufacturers are prepared to supply Diesels above 1,000 hp., while a few are building small sizes, down to 75 hp. These small units are quite successful in ice and lighting plants because of the increased economy over other types of units.

Considerable interest has been displayed in the solid- or pressure-injection oil engine. This type as constructed in the United States falls somewhat between the Diesel and the surface-ignition engine in sizes. Because of its simplicity and lower manufacturing cost it is being installed in industries where other types of prime movers are not so advantageous. Having an economy approaching that of the Diesel, it is to be expected that it will ultimately be built in units as large as 1,000 horsepower.

The surface ignition, or semi-Diesel, engine is in point of number and total horsepower the most popular oil engine in America. Because of its simplicity and range of sizes it is the logical prime mover in industries where the power demand is seasonal or small. The total output of the several semi-Diesel manufacturers exceeded the Diesel in horsepower. A large percentage of these engines were installed in irrigation plants, small central stations and oil-field pumping stations.

No radical changes in semi-Diesel design took place during the year. The tendency has been toward increas-

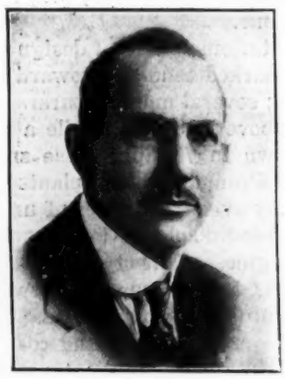
ing the engine capacities and in eliminating water-injection. Several manufacturers are building units as large as 300 hp. The low compression pressures carried in former years have been gradually increased; at present several engines have compressions as high as 250 lb. per sq.in., thus becoming to all intents solid-injection engines. The increased pressures carried have resulted in a decrease in the amount of uncooled surface in the combustion chamber or in the total absence of this feature; this has eliminated to a considerable extent the head fractures which so frequently have been the subject of criticism.

The rapid decrease in petroleum reserves has halted extension in the use of oil under boilers. The increasing price and lowered quality of coal have served to direct more attention to the oil engine with its high thermal efficiency. The wide interest being displayed by engineers in the oil engine will ultimately result in its adoption in many industries where steam is not required for processes.

The gas engine found considerable application in industries such as steel works having a supply of coke-oven or blast-furnace gas. Many units of small capacities were installed in casinghead gas plants and in other oil-field work. Because of the decrease of the natural-gas supply few engines were purchased for industrial use. A considerable number of existing plants have installed producers and are operating the engines on producer gas. There is reason to expect a reawakening of interest in the producer-gas engine in the coming year, especially in anthracite and lignite producers.

# The Refrigerating Industry

BY F. E. MATTHEWS
Past President, American Society of Refrigerating Engineers



F. E. MATTHEWS

IN VOLUME of business the year 1920 has been a record breaker, refrigerating-machine manufacturers reporting that it has been the biggest year in their history. The habit of spending money for high-priced commodities by everyone seems to have given rise to demands for refrigerating equipment for many new uses which have not been offset by the high cost of such equipment. Beginning with a rush and ending with a slump, it has not been an ideal year for gross accomplishment and general satisfaction, however. Materials have been high and deliveries slow, labor has been scarce, overpaid and often proportionately inefficient. To the vendor of refrigerating equipment this has all spelled a "hard" season, and the present depression, in evident anticipation of lower prices, in which things will have opportunity to seek their own level and incidentally enable the builders to give merited consideration to the development of their lines, has not been altogether unwelcome. The last year has witnessed unusual activity along scientific lines, however, and as expressed by one prominent refrigerating engineer, "No longer is the industry marking time. It is moving forward." While it is difficult to credit many important accomplishments entirely to so short a period as one year, yet there are straws, some of no small dimensions, showing which way the wind blows.

Central-station power furnished under old contracts at what is now considered low rates, together with high labor turnover and other adverse labor conditions, has given no small impetus to the use of electric drives for small and medium-sized refrigerating and even large-sized ice-making plants. One of the largest manufacturers of refrigerating equipment gives total figures that indicate that 94 per cent of that company's output, which covers the entire field from the largest to the smallest, has been electrically driven. Whether the movement toward central-station power will continue when labor and fuel conditions revert more nearly to normal is extremely problematical.

The use of electric power can be credited with having accelerated the movement from distilled water or "crystal" ice toward agitated "raw-water" ice, which is only an intermediate step toward unagitated "raw-water," or "tombstone," ice which, while of an unattractive appearance, principally owing to the air entrapped during freezing, may nevertheless be as pure as the water of which it is made, considered in the majority of cases unquestionably fit for drinking purposes.

### IMPORTANCE OF THE ICE INDUSTRY

The importance of the ice industry can hardly be overestimated. It is stated by one of the best authorities that the ice consumption of the United States, which according to the preliminary reports of the Census Bureau has a total population of 105,600,000 (exclusive of Alaska and the insular possessions) consumes approximately 100,000,000 tons per year, about 0.947 tons or 1,894 lb. per capita per year. Per capita ice consumption increases with density of population, being approximately one ton in New York City.

Natural-ice plants are being rapidly superseded by ice-manufacturing plants, the former being used in and around New York only because of the investment which they represent. It is said that there is ample ice-manufacturing capacity in New York City and that natural ice is considered only as "reserve." Only about 10 per cent of the Greater New York consumption for 1920 was natural ice.

The substitution of large raw-water for small distilled-water plants represents enormous increase in economy, sometimes corresponding to a production of two and a half times as much ice per ton of coal as was possible by old methods. Needless to say, the cooling effect is the same for both natural and artificial ice.

The gross volume of cold-storage houses, which was so greatly increased during the war, has continued to further increase both by the erection of new and the conversion of old brewery plants. No less an authority than the specialist in storage of the Department of Agriculture is responsible for the statement that "a recent survey of the cold-storage and packing industries of the country shows that there are 496,960,000 cu.ft. of space under refrigeration." This on the basis of a population of 105,660,000 amounts to 4.7 cu.ft. per capita.

Regarding consumption of frozen meat and refrigerated foodstuffs of all kinds, another eminent authority

on cold storage has said that, introduced to it during the war, Continental Europe is consuming these products at a rate that would have required a century to develop under ordinary conditions and that in his opinion "frozen fresh meat is now considered as a standard by army authorities in every European country worth mentioning."

Whether or not due to the *esprit de corps* resulting from general unselfish service for the common cause of winning the war, the last year has been marked, as another able engineer has said, by a most remarkable co-operation in industry, a movement toward co-ordination of scientific truths, practical experience, operating conditions and business methods, manifested by willingness to admit that there is room as well as need for improvement in production efficiency, and to try earnestly to realize a larger ratio of useful work to expended energy.

### Refrigerating-Machine Design

The field of refrigerating-machine design produced little that was spectacular during 1920. There was a tendency on the other hand to get down to solid reality regarding some of the more novel developments of a few years past. It cannot be said, however, that this may not represent true progress. In this connection one subject demands recognition.

The tendency toward high efficiency, high-speed engines and compressors, though slow, is nevertheless believed to be sure. Not only is the unaflow type of engine being adopted for driving ammonia compressors, but attention is being directed to a further extension of the unaflow principle into the compressor itself, which, being equipped with feather valves, is capable of high-speed operation.

It is also encouraging to note that commercial progress is being made along the lines of compound and multiple-effect compression. Acceleration of progress along these lines is to be expected as increased attention is commanded by necessity for more economical operation.

### Activities of Refrigerating Engineers

In the American Society of Refrigerating Engineers the year has chronicled a number of important events. The practical completion of a Code of Municipal and State Regulations for Refrigerating Plants and Refrigerants, by a committee of the society, made sponsor for this work by the National Standards Committee of the United States Bureau of Standards, marks material progress in the industry, since its accomplishment could have been made possible only by the intimate co-operation of competitive interests with representatives of the National Board of Fire Underwriters, the Interstate Commerce Commission, insurance, and other organizations. When this code shall have received the stamp of approval of the National Standards Committee, it will have progressed far toward general adoption by municipal and state vested authorities. The advantages of uniform regulatory legislation are too obvious to warrant comment.

The sixteenth annual meeting of the society had the distinction of being the occasion for the presentation of advance copies of the Bureau of Standards' ammonia tables, the first tangible fruits of research which has been in progress toward that end for over eight years. It has been only through the substantial financial assistance procured by the society for the Bureau that this work has been carried to fruition.

Another event of this meeting well worthy of mention because of the importance of the work accomplished and because of the further manifestation of the spirit of co-operation, a duty first assigned to a committee of the American Society of Mechanical Engineers in 1903 has at last been discharged—that of establishing a standard tonnage basis for refrigeration. By the unanimous voice of the largest delegation of refrigerating engineers that ever convened, the American Society of Refrigerating Engineers accepted the report of the Joint A. S. M. E. and A. S. R. E. Committee fixing the standard rating of refrigerating machines using liquefiable vapor as the standard commercial tons of refrigeration performed under an adopted inlet pressure which corresponds to a saturation temperature of 5 F. (— 15 C.), and an outlet pressure which corresponds to a saturation temperature of 86 F. (30 C.). A standard commercial ton of refrigeration is defined as the rate of 200 B.t.u. per minute and the standard ton of refrigeration, a unit independent of time similar to foot-pounds per horsepower, as 288,000 B.t.u., which when performed in 24 hours is at the equivalent rate of 12,000 B.t.u. per hour, 200 B.t.u. per min., or 3⅓ B.t.u. per second. The American refrigerating industry now has a basic unit of maximum simplicity and practicability.

# Power-Plant Accidents

By S. F. Jeter
Chief Engineer, Hartford Steam-Boiler Inspection and Insurance Company

S. F. JETER

The last year's record of power-plant accidents is one that should give encouragement to those interested in their prevention. While it is impossible at this writing to collect any reliable statistics for even the greater portion of the year's power-plant accidents, it is apparent that major accidents are on the wane. Boiler explosions of a violent character have been relatively few, and while this might, in a measure, be attributed to the slacking up of industry, it has not been until the last few months of the year that this factor has been at all marked. The lap-seam crack has in years past been one of the chief causes of destructive boiler explosions, but relatively few such accidents were experienced during 1920. Two notable explosions of boilers occurred during the early part of the year, and no very satisfactory explanation for either was forthcoming.

The first was at the Interstate Iron and Steel Co., at East Chicago, Ind., and was attributed to a frozen steam-gage connection and safety valve. While it is entirely possible and probable that the gage connection may have been frozen and remained so during the seven and a half hours this boiler was under fire before the

explosion occurred, it is most unlikely that the safety valve could have been rendered inoperative for this length of time by such means. There appeared to be no weakness in the boiler structure to account for this accident, and no doubt an inoperative safety valve was the true explanation, causing the explosion of a sound boiler.

The second explosion was at the Puget-Sound Traction and Light Co. This was an oil-fired boiler and exploded after being under fire for about one hour. There was nothing about the condition of the boiler to explain the accident. One theory advanced was that the rapid raising of steam in the boiler, which was made possible by the fuel used, was in some way responsible for the explosion. While nothing in the account of this accident would bear out such an explanation, it is possible that a heavy explosion of gas in the setting of the boiler may have caused the breaking of some of its parts, which in turn may have caused the explosion of the boiler itself.

### History of Boiler Explosions

The Hartford Steam Boiler Inspection and Insurance Co. published in the October issue of *The Locomotive*, a set of diagrams giving the history of forty years of boiler explosions as collected by them from various sources. These diagrams show that there is a marked tendency toward the lessening of the toll of life and limb in such accidents in the United States. While this tendency may be explained in part by the more complete collection of data on which the diagrams are based, it is possible that greater attention to construction details, which tend to eliminate destructive explosions, and better care and management, which has been the result of laws governing operation, may be factors of importance in producing this result.

A careful review of the records of an insurance company having more than 100,000 boilers under its care during two decades shows that in the last decade the accidents in connection with both fire-tube and water-tube boilers have resulted in approximately half as many personal injuries and deaths per explosion as was the case in the previous decade.

### Flywheel Explosions Less Destructive

Flywheel explosions during the year have also been less destructive than usual. Few of these have been from the most prolific cause of such accidents in the past, namely, the blocking of governors. The operating engineer appears to have realized at last that blocking a governor on an engine is about on a par with overloading a safety valve on a boiler. Most of the runaways that have been experienced appear to have been caused by the failure of some portion of the governor or valve-gear mechanism, the weakness of which could not well be determined previous to the accidents. Locating some of the governor connections or safety-stop mechanism in line with the flywheel so that the breaking of the belt could cause these speed-limiting devices to be inoperative, was the cause of some of the accidents to flywheels.

The "big brother" of the reciprocating engine, the steam turbine, has also behaved remarkably well during the last year. Although in 1919 there was apparently an epidemic of turbine accidents, only one of note has been recorded during the last year. This explosion was at the City of Regina, Canada, where a 5,000-kw. turbine was completely demolished, the accident being attributed to the breaking of the shaft. Other turbine accidents during the year have been limited almost exclusively to blade stripping.

Notwithstanding the fact that autogenous welding has been hedged in by rather strict rules governing its application to boiler and pressure-vessel work by the various state departments and the insurance companies, there were a number of failures attributed to the use of this process during 1920. Without doubt rapid strides are being made to restrict its application to uses to which it is suited, as well as improving the making of the welds by those interested in the art. The fact that it requires such a small outlay in money to secure the necessary equipment to perform such work and that irresponsible parties are thereby permitted to undertake work for which they have had no adequate training, is hurting the industry as a whole. It seems evident that at the present time its use in boiler and pressure-vessel work should be restricted to parts where safety is not vitally dependent on the strength of the welds.

### Autogenous Welding in Locomotive Boilers

The annual report of Chief Inspector A. G. Pack, of the Bureau of Locomotive Inspections of the Interstate Commerce Commission, for the fiscal year ended June 30, just published, has the following comment on the use of autogenous welding in locomotive work:

> In my last annual report attention was directed to some violent explosions where the failure of seams united by the autogenous process was a strong contributing factor to the seriousness of the accident. During the year a number of accidents have been investigated where the autogenous welding failed with evident increasing fatal results, in view of which, and considering that the percentage of failures of such welds involved has not decreased, I am still of the opinion that such methods should not be applied on any part of the boiler where the strain to which the structure is subjected is not carried by other construction which fully conforms to the requirements of the law and rules, nor in the so-called low-water zone of a firebox, where overheating and failure are liable to occur. This should apply with equal force to all parts of the locomotive and tender subject to severe strains and shocks, where, through failure, accidents to employees and the traveling public might occur.

Taken as a whole the year 1920 is one of much encouragement and credit to those concerned with the prevention of power-plant accidents. With the continuance of improved conditions noted in this field, we may hope soon to arrive at the point where foreign countries cannot point the "finger of scorn" at us with the claim that we value the "almighty dollar" above the safety of life and limb.

## Progress in Accident Prevention

By Sidney J. Williams
Secretary and Chief Engineer, National Safety Council, Chicago

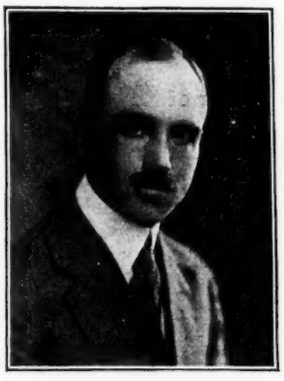
THE various kinds of power equipment and power plants in which the readers of *Power* are interested —steam, electric, water, refrigeration and the like— have one thing in common from the safety point of view: In each of them tremendous energy is generated or used, and the accidental liberation of this energy is likely to result not only in serious injury or death to persons near-by, but also in large property damage and complete interruption of the industrial enterprises in which the power is employed. In other words, most serious power-plant accidents are a striking illustration of the fact that safety engineers have found to be true in

somewhat less striking fashion in all industries—that accidents are symptoms of inefficiency and, as a rule, cause a loss in production far more costly than the compensation that must be paid to the injured persons concerned.

As an example of what it is possible to accomplish in preventing accidents of this sort through a combination of improved equipment and educational work, the experience of one of the largest electric-light and power companies in the country may be cited. This company had 33 fatalities during five years preceding the establishment of an up-to-date safety department, while during the five years since the department was established in spite of increasing business there have been only 12 fatalities.

### Mechanical Equipment Improved Through Standardization

On the mechanical side it has already been indicated that to build and maintain power equipment so it will not blow up or break down is even more vitally important than in the case of machinery in general. Up-to-date power-plant engineers are fully aware of this fact and are constantly striving to improve the safety and reliability of the equipment which they manufacture or operate. The chief difficulty lies with obsolete equipment, generally in the hands of improperly qualified persons. Many of these cases can be reached only through pressure from insurance carriers and state authorities. The work of these agencies is made considerably more effective by the formulation and adoption of uniform standards or codes, and it is encouraging to note that considerable progress has been made in this respect during 1920. The Boiler Code has been more widely used. The Bureau of Standards has prepared a third revision of the National Electrical Safety Code. In this new edition a number of changes, mostly in matters of detail, have been made as a result of experience, and while the sections dealing with overhead crossings do not yet represent complete agreement of all interests, the code as a whole is a forward step of the greatest importance.



S. J. WILLIAMS

To develop more complete standards on some of the subjects touched on in the Electrical Safety Code, the Electrical Safety Conference has been organized and includes the Bureau of Standards, Underwriters' Laboratories, the National Workmen's Compensation Service Bureau, the Electric Power Club, and the Associated Manufacturers of Electrical Supplies. The Electrical Safety Conference has formulated and published tentatively Safety Rules for Industrial Control Equipment, which, with perhaps some revision resulting from experience, will undoubtedly be accepted as standard in that field.

A uniform color scheme for designating various kinds of pipe lines is to be prepared by the American Society of Mechanical Engineers and the National Safety Council jointly, sponsorship for this standard having been assigned to these organizations by the American Engineering Standards Committee. Other organizations that are interested and that have been consulted have all expressed an entire willingness to co-operate in formulating a standard color scheme that can be generally recommended for new installations and to which existing installations can gradually be brought to conform. Every power-plant executive recognizes that it would be very desirable, from the viewpoint of efficiency as well as safety, to have a uniform color scheme in general use and thus avoid confusion when employees shift from one plant to another.

### The Human Element

The other, or human, element in safety work has to do with the prevention of accidents by educating or training employees to do things the safe rather than the unsafe way. When this thought is introduced, some engineers instinctively react with, "It's not my fault if some fool drops a lump of coal on his toes or burns himself on a busbar." This point of view overlooks several important facts. For one thing, many serious accidents as well as a great number of minor ones, are caused by ignorance or carelessness; in fact, no equipment is safe if carelessly operated. Only an organized effort to make all employees careful in all matters both great and small will give adequate protection against the very serious accidents which, as everyone knows, are likely to result from improper maintenance or improper operation of a boiler, steam engine, electric generator or any other power equipment. The truth of this is evidenced by the figures already quoted, of a remarkable reduction in fatal accidents accomplished by a large electric company by means of an organized safety campaign in which education of employees played a leading part.

### Progress in Teaching Workmen to Be Careful

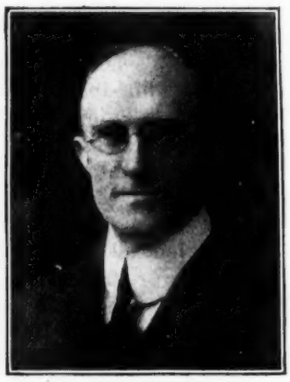
In the handling of electrical power, the working out of safe operating practices by the company and the education of the men in following these practices is particularly important, especially the practices to be followed in throwing power onto a line or into machinery that has been idle or under repair. The proceedings of the Public Utilities Section of the National Safety Council contain some valuable information as to methods that have been found most successful by a number of the large companies.

How to teach workmen to be careful is a big subject, and it cannot be covered here. Suffice it to say that these educational methods, by means of bulletin boards, inspection committees, meetings and, above all, proper supervision, have been definitely worked out through the experience of hundreds of companies in all industries, which have been successful in eliminating from 50 to 90 per cent of their accidents. The year just passed has seen very encouraging progress along this line. Some companies have carried to further perfection the organized safety effort begun in earlier years. Others have taken up this work for the first time and have found it profitable. Further progress of the same sort may confidently be looked for during the new year and thereafter.

# Progress of Engineering Societies in 1920

By Calvin W. Rice
Secretary, American Society of Mechanical Engineers

THE outstanding event in engineering circles is the awakening of the consciousness of obligation to society, or, as has been recently expressed, social consciousness; in the Interprofessional Conference, a year ago in Detroit, this quality was described as social-mindedness. This was shown by the conception and inauguration of the American Engineering Council, representing all the engineering societies, both national and local, throughout the United States. That it attracted Herbert Hoover sufficiently for him to accept the presidency is evidence that the idea represented unselfish devotion, on the part of the engineering profession, to the good of the community and the nation. Few scientific bodies, engineering, medical, legal and other professional societies, in this country or abroad have, until very recently, stated their objects to be other than strictly technical and for the advancement of the profession. With scarcely a half-dozen organizations of a technical character anywhere in the world having grasped the new spirit, how remarkable it is to read the following as the avowed purpose of the Federated American Engineering Societies:



CALVIN W. RICE

> As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public welfare demands the best efforts men can put forth, now, therefore, the engineering and allied technical societies of the United States of America, through the formation of the Federated American Engineering Societies, realize a long-cherished ideal—a comprehensive organization dedicated to the service of the community, state and nation.

It had been hoped that Engineering Council might be expanded by evolution into the American Engineering Council in distinction to dissolution of the older body. It is, however, gratifying to state that ten of the delegates to American Engineering Council were formerly members of Engineering Council. With Mr. Hoover as president, ably assisted by Calvert Townley, Dean Dexter S. Kimball and the former chairman, J. Parke Channing, as vice presidents, all the past efforts in co-operation and in public movements will be conserved and carried forward under the new auspices.

One element of service which is very difficult to analyze, is the obligation of the professional societies to take cognizance of the matter of remuneration for the professional engineer. That it is serious has been recently emphasized by the fact that it occupies a major part in the address of the new president of the Institution of Civil Engineers. This situation in the United States was aggravated greatly during the war and became acute in many places. Engineering Council recognized the situation and appointed committees to co-operate with Government agencies; and conservative schedules for the classification of professional men and their salaries have been prepared.

In this connection credit should be given to one very large American association, which has specialized in its efforts to meet this situation and has grown so that it has naturally felt that perhaps this and other activities that it undertakes should be retained by it rather than made an activity of all societies jointly. The spirit of co-operation for the good of the whole profession should be the impelling motive, and it is entirely possible for both organizations to serve. However, a feeling in engineering circles is that there are too many societies and that concentration of effort should be somehow effected.

One of the well-nigh completed movements inaugurated under the auspices of Engineering Council and to be assumed by American Engineering Council is that of the Department of Public Works. A bill to this end was introduced in the last Congress but failed to pass, and there has been introduced into the present session a comprehensive bill for the reorganization of all bureaus of the Government, and it is generally understood that the Department of Public Works will be first to be consummated.

Another successful undertaking of Engineering Council which will now be assumed by American Engineering Council is the relief of the Patent Office by enlarging the staff and increasing the remuneration. Several successful hearings have been held and bills introduced.

In keeping with this spirit of service is the still further gift this year of $200,000, making a total of $500,000, by Ambrose Swasey of Cleveland, past-president and honorary member of the American Society of Mechanical Engineers, and the original donor and founder of the Engineering Foundation, devoted to research for the benefit of mankind through the instrumentality of the engineer.

To those not familiar with the conception of the idea, it may be well to recount that this Foundation is patterned after the Cleveland Foundation, which was started a number of years ago, with the identical sum ($200,000) with which Mr. Swasey began in the case of the Engineering Foundation. The Cleveland Foundation has grown to hold in excess of thirty million dollars to be devoted to the good of the citizens of Cleveland. Over a score of other cities in the United States have established similar foundations.

Another pleasant effort with great potential usefulness is the American Engineering Standards Committee. Great Britain has had a similar activity for nearly thirty years, sponsored jointly by the engineering societies, the Government and industry. In the United States this has been attempted for a number of years, but only recently consummated, and only during the last year have standards been promulgated. Success, however, has been attained and now, in addition to the leading engineering societies, several departments of the Government are represented.

A pleasant incident of the year, which must not be regarded as too important, but nevertheless of interest, is that one of the national societies took occasion to celebrate its fortieth anniversary. There are several

societies that can boast greater age and, absolutely speaking, none of the American societies can be considered ancient. Nevertheless, by virtue of the fact that the engineer is now able to secure greater attention on the part of the public, on the occasion of this fortieth anniversary greetings were received from the President-Elect and from the Vice-President-Elect of the United States.

# The Honor Roll for 1920

By Thomas Wilson
Western Editor, *Power*

For their achievements in science and engineering a number of men prominent in the field were honored during 1920. An engineering review would not be complete without mention of the recognition given them by the profession. Toward the middle of the year the John Fritz Medal was presented to Orville Wright, pioneer in the development of the airplane. It was the fifteenth award since the initial presentation of the medal to John Fritz in 1902. Carl G. Barth, whose work on the fundamental formulas in cutting metals has received world-wide recognition, was elected an honorary member of the Taylor Society, the national organization for the promotion of science in management. Only two other men have been so honored by this body. By the American Institute of Electrical Engineers the annual presentation of the Edison Medal was made to William LeRoy Emmet "for inventions and developments of electrical apparatus and prime movers." Mr. Emmet's work with the General Electric Co. is well known and particularly his latest experiments with the mercury boiler and turbine.

THOMAS WILSON

By America two prominent European engineers have been honored with the Franklin Medal: Sir Charles A. Parsons, the eminent British engineer and scientist who perfected the reaction steam turbine, and Prof. Svante A. Arrhenius, of the Nobel Institute, Stockholm, Sweden. Progress has been made with the James Watt Memorial. Part of the 150,000 pounds sterling to be raised has been collected. It is the intention to endow a professorship of engineering to be known as the James Watt Chair, at the University of Birmingham, for the promotion of research in the principles underlying the production of power. A memorial volume is to be published and a James Watt Memorial Building to be erected and used as a museum for examples of the work of Watt and his contemporaries, Boulton and Murdock.

From Europe comes the award of the Nobel peace prize to President Wilson for his untiring efforts in this direction. As usual the ceremony was held in the Norwegian Storthing. The award carries with it a grant of about $40,000, which is one-fifth of the annual interest on about $9,000,000 left for that purpose by Alfred B. Nobel, the Swedish scientist and inventor of dynamite, who died in 1896. In the past the only Americans receiving this prize were Theodore Roosevelt and Elihu Root.

Men honored by selection to lead the engineering organizations closely related to the power field are: Herbert Hoover, Federated American Engineering Societies; Edwin S. Carman, American Society of Mechanical Engineers; A. W. Berresford, American Institute of Electrical Engineers; Martin Insull, National Electric Light Association; E. S. Jefferies, Association of Iron and Steel Electrical Engineers; A. D. Schofield, American Boiler Manufacturers' Association; Alfred Johnson, National Association of Stationary Engineers; W. Scott Price, American Order of Steam Engineers; Dr. Vernon Hill, American Society of Heating and Ventilating Engineers; J. L. Hecht, National District Heating Association; Fred Ophuls, American Society of Refrigerating Engineers; C. W. Koehler, National Association of Practical Refrigerating Engineers; Joseph M. Lonergan, Smoke Prevention Association; Dr. George F. Swain, Water Power League.

## Necrology

In commemoration of those who have departed during the year, we list the following from the columns of *Power:* Pierrepont Bigelow, treasurer of the Bigelow Co.; George R. Starr, prominent in N. A. S. E. circles; Cyrus Thurston Johnson, mechanical and electrical engineer, of St. Paul; John A. Randolf, of the Westinghouse Electric and Mfg. Co.; Melvin B. Newcomb, chief engineer of the rubber machinery department of the Wellman-Seaver-Morgan Co.; Charles E. Barber, inventor of the Barber marine engine; Dr. John A. Brashear, noted for his mechanical achievements with astronomical instruments and past president of the American Society of Mechanical Engineers; Frank M. Babcock, engineer of the Veazie hydro-electric station of the Bangor Railway Co.; John Wesley Hyatt, inventor of the Hyatt roller bearing; Whitfield P. Pressinger, vice-president of the Chicago Pneumatic Tool Co.; O. C. Woolsen, mechanical engineer, of Newark and New York City; Professor John Perry, one of England's foremost engineers and authors; A. C. Buzby, president and founder of the Keystone Lubricating Co.; William M. Barr, well known in the world of technical literature for his works on pumping machinery, boilers and furnaces, combustion of coal and his handbook on industrial engineering; Professor John R. Allen, long recognized as an authority in heating and ventilation and recently director of the Bureau of Research of the American Society of Heating and Ventilating Engineers; Percy B. Taylor, prominent consulting engineer, of Newark, N. J.; Hobart D. Frary, assistant professor of steam and gas engineering, University of Wisconsin; Prof. E. M. Shealy, for a number of years associate professor of steam engineering in the University of Wisconsin and perhaps best known by his books on "Steam Boilers," "Heat" and "Steam Engines"; George Tangye, famous English engineer of the old school, well known from the Tangye line of engines; Arthur E. Hauck, president of the Hauck Manufacturing Co., maker of oil-burning appliances, furnaces and forges; William Krouse, well known in N. A. S. E. circles; William T. Price, designer of the Price solid-injection oil engine and latterly chief engineer of the oil-engine department of the Ingersoll Rand Co.

# Effect of Load Factor on Steam-Station Costs*

## Analysis of Effect of Load Factor on Generating Costs—Importance of Correctly Estimating Future Load Factor Before Selecting Equipment—Effect of Future Load Factor on Location of Plant—Of Variations in Load Factor on Operating Expenses

BY PETER JUNKERSFELD
Engineering Manager, Stone & Webster, Boston, Mass.

THE annual load factor is an indication of the number of hours per year that the dollar of capital expenditure in a steam station can be kept at work. The expense of using this dollar is just as great when it is working 100 hours or 1,000 hours or the full 8,760 hours in a year. Interest and other fixed charges have no shutdowns, no lost time.

The returns are, however, in direct proportion to the number of hours in the year that this dollar is kept at work, or in other words, to the annual load factor. For example, if the annual load factor of a power station is increased from 30 per cent to 60 per cent, the fixed charges per kilowatt-hour are cut in half.

Load factor is the ratio of the average to the maximum output during any definite period of time. It is usually based upon an average demand for say fifteen minutes and upon output for a day, week, month or year. It may apply to a system having many generating stations and serving many communities or merely to one power station or even one unit in a power station.

### STABILITY OF SYSTEM LOAD FACTOR

The annual load factor of a central-station system nearly always changes very slowly. Special efforts to secure a well-diversified business, together with the new uses of electricity which are constantly arising, contribute substantially to improvement in load factor.

The ordinary factory, working a 44-hour week with the usual lay-off for holidays, keeps a power station busy for only one quarter of the 8,760 hours in a year. Residence and street lighting tends to improve load factor in the summer, but is less and less of a help as the days grow shorter, until it finally changes from a blessing to a burden upon the plant during the months when the lighting peak overlaps the end of the factory or business day.

### INVESTMENT AS AFFECTED BY LOAD FACTOR

The cost of energy is made up of two principal elements—the fixed charges, and the operating and maintenance expense. Let us see first how the fixed charges are affected by load factor. In this case we must use annual load factor because fixed charges run on year after year. Suppose that one power station has cost $100 per kilowatt. At 15 per cent per annum the fixed charge per kilowatt would be $15 each year. With an annual load factor of 30 per cent the fixed charge per kilowatt-hour would be 0.57c. If the load factor is increased to 70 per cent, we find this fixed charge per kilowatt-hour cut to 0.24c.

This comparison, of course, is not wholly a fair one, because a station properly designed to operate at 70 per cent load factor would cost more to build (although less per kilowatt-hour to operate) than one of equal capacity but properly designed for a 30 per cent load factor. Its boilers would have been rated differently, turbines of different individual capacities and perhaps different efficiencies might have been selected, the condensers would have been designed more liberally, and higher-efficiency equipment would have been selected wherever economical with the higher load factor. Even supposing that these features boosted the first cost $20 per kilowatt, we would still save probably one-tenth of a cent per kilowatt-hour in the combined fixed charges and operating expenses, in comparison with an attempt to impose a 70 per cent load factor on a plant properly designed for 30 per cent.

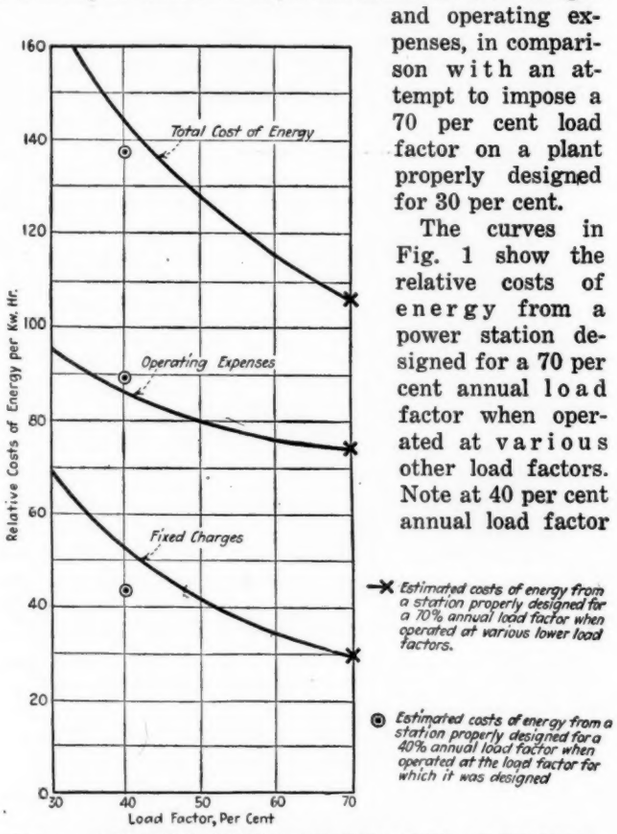



FIG. 1. RELATIVE COST OF GENERATING AT VARIOUS LOAD FACTORS, SHOWING EFFECT OF DESIGNING A STATION FOR TOO HIGH A LOAD FACTOR

The curves in Fig. 1 show the relative costs of energy from a power station designed for a 70 per cent annual load factor when operated at various other load factors. Note at 40 per cent annual load factor the lower cost of energy obtained from a station designed for a 40 per cent annual load factor. The lower fixed charges on the 40 per cent station more than offset its higher operating expenses.

Financial loss will result whenever it becomes necessary to operate a power station at a substantially higher or lower annual load factor than that for which the station was properly designed. The load factor of a system as a whole usually changes slowly, even with a rapidly growing business. Where several stations supply a single system under one management, the load factor on each station should be adjusted so as to secure most efficient operation of the system as a whole.

*Paper presented before the Power Section of the American Society of Mechanical Engineers, Dec. 10, 1920.

Suppose that the station mentioned previously was one of several stations supplying a light and power system. Assume that at the time of its construction it was intended to operate it on a base load at a 70 per cent annual load factor, whereas the other stations supplying the system were to be operated only to carry peak loads, on account of their inferior efficiency. Assume also that within a few years, on account of rapid growth of load, another larger station, not previously contemplated, was built, having greater efficiency, and that the station first mentioned no longer was operated on the base load, but was operated at a 30 per cent annual load factor. We at once see that we are then using an unnecessarily expensive tool, where one costing $20 less per kilowatt would do the work just as well and at less total cost per kilowatt-hour.

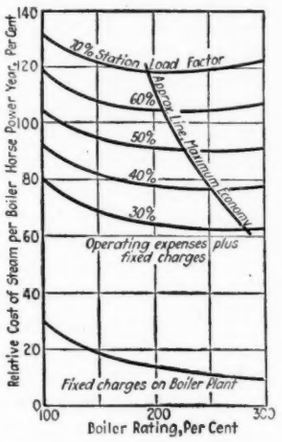



FIG. 2. EFFECT OF ANNUAL LOAD FACTOR ON ECONOMICAL BOILER RATINGS

Similar financial losses may occur in a single power station supplying a rapidly growing load. When a new unit is installed in a power station it is important to know approximately how soon another will be required. Each succeeding unit is frequently larger than the preceding ones, up to the practical limit of size available for the particular purpose. The increased size is usually accompanied by increased efficiency. The units of highest efficiency carry the bulk of the load. The extra price paid for extra efficiency in a power-station unit sometimes results uneconomically, due to another larger unit being installed earlier than anticipated.

The cost of an error of judgment or the extra expense due to an unexpected change in the annual load factor at which a station or unit is operated, may therefore be considerable.

## Central-Station Location

The location of a central station relative to its raw-material supply and to the point of delivery of its finished product should be influenced greatly by load factor.

In the selection of a site condensing water is usually given first consideration. Transporting it adds greatly to the station fixed charges, while cooling it artificially causes inefficient operation.

A very low annual load factor likely to prevail over a long period of years sometimes justifies artificial cooling of condensing water, if the station may thereby be located near the load with a minimum investment in transmission lines or cable.

With a larger annual load factor the additional operating expense due to cooling the condensing water might be so large as to entirely outweigh the fixed charge on the transmission line, so that the plant would be located where condensing water is available. In weighing the relative costs, the operating expense at either location must be added to the fixed charge before the more advantageous site can be determined.

Load factor determines the quantity of fuel consumed by a power station and has a considerable influence on the efficiency with which it is burned. Starting, stopping and standing by, as well as operating equipment only partly loaded, as is required at low daily load factors, inevitably result in a high coal rate. It is the engineer's task to weigh carefully cost against efficiency and load factor, so as to select properly.

One of his first problems, if the station is a new one, is to determine the boiler pressure. High efficiencies can be obtained with high boiler pressure. Construction cost, on the other hand, increases rapidly with increases in pressure. The economical pressure should usually be determined by the extent of the use of the equipment; that is, by the annual load factor.

An arbitrary assumption of steam pressure, or an arbitrary selection of certain principal items of equipment, may so definitely restrict the design that the full financial benefits of a consideration of load factor in the later selection of additional equipment may not be realized. The most far-reaching power-station engineering is done during the conception of the project, and it is at this time, when fundamental decisions are being made that will either help or hinder the engineering, construction and operation of the station, that load factor should be given the greatest consideration. This means not only the immediate load factors, but also the load factors that could reasonably be expected during the probable life of the equipment.

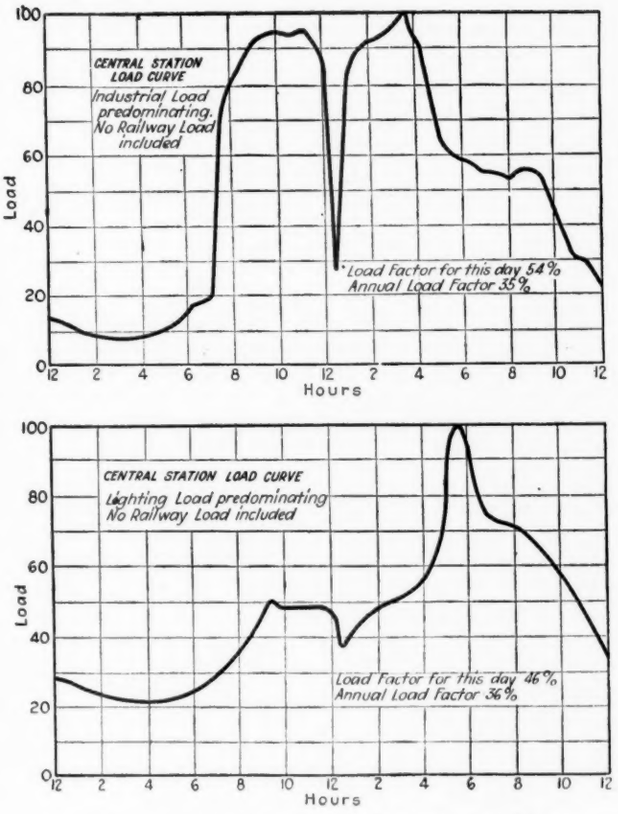



FIG. 3. TYPICAL WEEK-DAY LOAD CURVES

Reference has been previously made to the differences in boiler rating for which central-station boiler plants would be designed for operation at different annual load factors. This depends on the cost of the boilers and combustion equipment, their efficiencies at various loads, the cost of labor and maintenance at various loads and the fuel required for banking and starting. Fig. 2

shows, for a particular case selected as an example, the effect of load factor on the most economical rating at which boilers should be operated to carry the station peak load. Notice the manner in which this economical rating increases as the load factor diminishes.

The rating is only one of a number of boiler-plant problems that arise and that must be solved on the basis of load factor. The type and design of the boiler,

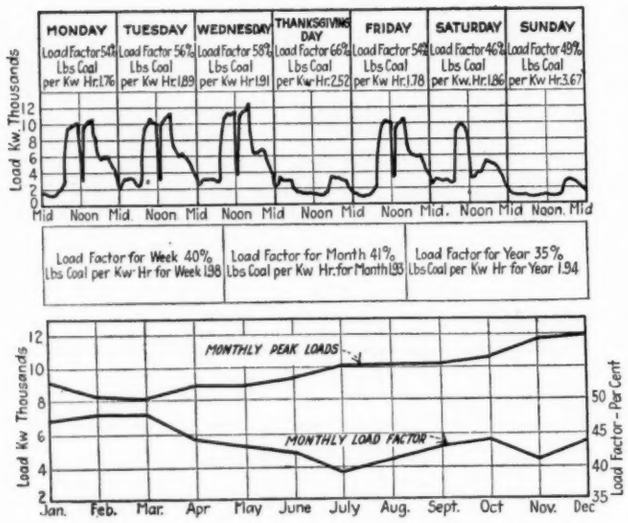

MONDAY
Load Factor 54% Lbs Coal per Kw Hr. 1.76
TUESDAY
Load Factor 56% Lbs Coal per Kw Hr. 1.89
WEDNESDAY
Load Factor 58% Lbs Coal per Kw Hr. 1.91
THANKSGIVING DAY
Load Factor 66% Lbs Coal per Kw Hr. 2.52
FRIDAY
Load Factor 54% Lbs Coal per Kw Hr. 1.78
SATURDAY
Load Factor 46% Lbs Coal per Kw. Hr. 1.86
SUNDAY
Load Factor 49% Lbs Coal per Kw Hr. 3.67
Load Kw. Thousands
Mid Noon Mid Noon Mid Noon Mid Noon Mid Noon Mid Noon Mid Noon Mid
Load Factor for Week 40% Lbs Coal per Kw Hr for Week 1.98
Load Factor for Month 41% Lbs Coal per Kw Hr. for Month 1.93
Load Factor for Year 35% Lbs Coal per Kw Hr for Year 1.94
MONTHLY PEAK LOADS
MONTHLY LOAD FACTOR
Load Kw Thousands
Load Factor - Per Cent
Jan. Feb. Mar. Apr May June July Aug. Sept. Oct Nov. Dec

FIG. 4. TYPICAL WEEKLY AND MONTHLY LOAD CURVES

the length of its tubes, the number of rows of tubes wide and the number of rows high, the combustion equipment, the location of the bridge wall and the baffles, and the size and shape of the furnace should all be determined by reference to the total load factor on the station, as well as the anticipated load factor on the individual boilers. The use of economizers even in large stations cannot be justified at very low load factors.

The economic selection of turbo-generator units may be made upon the basis of size, speed and other factors. The speed influences both the cost and the efficiency of the unit and is very important in relation to the average annual load factor at which the machine will operate over a period of years.

The selection of a surface condenser should be made largely from the point of view of annual load factor. A high load factor anticipated for a unit for a long period of time would justify a condenser of large surface so as to obtain a high efficiency in operation.

The foregoing does not attempt to mention the many power-station appurtenances contributing to higher efficiency which should be omitted from the station designed to operate at low annual load factor, but which might be justified if the station annual load factor were higher. On the other hand, it should not be overlooked that there are some instances in which it is more economical to buy more expensive equipment for low load-factor conditions than for higher load-factor conditions. An example comes to mind in which it was necessary to transmit power through step-up transformers, at about a 30 per cent annual load factor. The load curve was typical of a factory load in which the maximum amount of power was supplied more or less continuously for about eight hours of the working day with a much smaller amount of power for the remaining sixteen hours. When it came to the purchase of the transformers, all of those offered had the same full-load efficiency. The transformers of the lowest bidder, however, had the highest no-load losses. The partial load conditions to be met were discussed, certain requirements more clearly stated, and some changes in design suggested. New bids were received, and the transformers finally selected were designed for the particular conditions but at an advance in price. The increase was due to the additional cost of the higher-grade materials that were selected for use in the transformer construction and the changes in design that were made on account of the particular load conditions. The use of these materials and their additional cost would not have been justified if the transformers had been operated at a higher load factor, as the full-load efficiency was not increased by the changes made. The additional cost of the transformers was saved in about two years, because of the lower 24-hour losses.

The engineers who design a power station fix the upper limit of its operating efficiency by the selection and arrangement of equipment. If this is properly done for the particular load and load factor, the total cost of power from that station, including the fixed charges upon the investment, will be a minimum if the station is properly operated and maintained. If the selection and arrangement are not made wisely, the station thereafter will be handicapped either by excessive fixed charges or by excessive operating expenses.

## Operating Expenses

The influence of a change of load factor on operating expenses has been briefly referred to heretofore, but it may be of some interest to point out its effects.

The expense of superintendence and station administration is more or less fixed for a given size of station, so that a change of load factor would not influence it in total amount. Boiler labor may be considered as composed of two parts, one of which depends on the capacity of the station alone, and the other of which, for a station of given capacity, would vary with the daily load factor on the station. Mechanical labor would be influenced by daily load factor to a less degree, but would depend on the number and size of the main generator units. The electrical labor would be influenced more by the number of feeders or the number of kinds of current distributed than anything else.

Fuel is usually an item of greater expense than all others and, as pointed out previously, it is dependent on load factor. Efficiency in the use of fuel is greater at the higher load factors. As an example of the effect of load factor upon station-operating expenses, a hypothetical case may be taken of a station containing units of various sizes which might have operating expenses as shown in the tabulation. Note the fuel expense as compared with the total.

| | Operating Expenses Cents Per Kw.-Hr. | | |
|---|---|---|---|
| Annual load factor | 30 per cent | 50 per cent | 70 per cent |
| Fuel | 91 per cent | 85 per cent | 71 per cent |
| Labor for operation | 10 per cent | 07 per cent | 06 per cent |
| Maintenance, material and labor | 08 per cent | 05 per cent | 04 per cent |
| Miscellaneous, material and labor | 04 per cent | 03 per cent | 03 per cent |
| Total | 1.13 per cent | 1.00 per cent | 84 per cent |

Load factor alone does not by any means determine the amount of fuel which a central station of a given size should consume. The shape of the daily load curve is of almost equal importance in its effect upon the efficiency with which the fuel is burned. The shape

of the load curve is in turn dependent on the character of the business served by the central station. This is illustrated by the two examples of central-station load curves given in Fig. 3. In both instances the lighting peak overlaps the day load, but on account of the predominance of factory load in the business of one of these stations an exceptionally favorable shape of load curve is obtained, as well as a relatively high load factor for the day.

It is interesting to note, however, that the load factor for the year is practically the same in these two cases. This is owing to the effect of the extremely low loads that obtain on Sundays and holidays. For these two conditions, illustrated by Fig. 3, having practically the same annual load factors, the better annual coal rate would be obtained with the one having the more favorable shape of load curve; that is, with the one in which the factory load predominates.

Fig. 4 shows how the load and load factor vary from day to day and month to month for a business in which factory load predominates. The beneficial effect of high load factor on Thanksgiving Day, for example, is much more than offset by the relatively small load on the station on that day. Notice how the load factor for the week and for the month are practically the same. The load factor for the year is somewhat lower owing to the variation in maximum demand throughout the various seasons. In general, the better coal rates are obtained with the higher load factors, although this is greatly influenced by peak load, quality of fuel and skill in operation, all interesting subjects but beyond the scope of this discussion.

That load factor has a great influence in determining central-station energy costs is not a new thought. I have attempted, however, to indicate the price which may sometimes be paid in increased fixed charges or increased operating expenses on central-station equipment as a result of incorrectly predicting, through inexperience, insufficient knowledge of the conditions or other causes, the average load factor at which the equipment will operate throughout its life. An operating organization can attain favorable total station costs only within the limits fixed by those who wished the power station upon them.

## Diesel Engine Pointers

The fuel tank, which is generally placed overhead, should be of limited capacity. There is a fire hazard when a large amount of oil is placed above the engine. It is preferable to place a larger tank under the floor and use a small pump to circulate the oil continuously into the upper tank with an overflow to the lower tank.

The main fuel-oil storage tank, whether of steel or concrete, should be placed at least five feet outside of the building; a greater distance is better.

The storage tank should be vented to allow the escape of oil vapors. The suction line should be connected to a float so arranged that the end of the pipe cannot touch the bottom, even when the tank is practically empty.

In cold climates it is necessary to place heating coils in the oil tanks to enable the pump to handle the oil. With Mexican oil this is necessary even in the Southern States. If a coil of pipe be wrapped around the exhaust pipe, usually ample heat is supplied to the water in the heating coils.

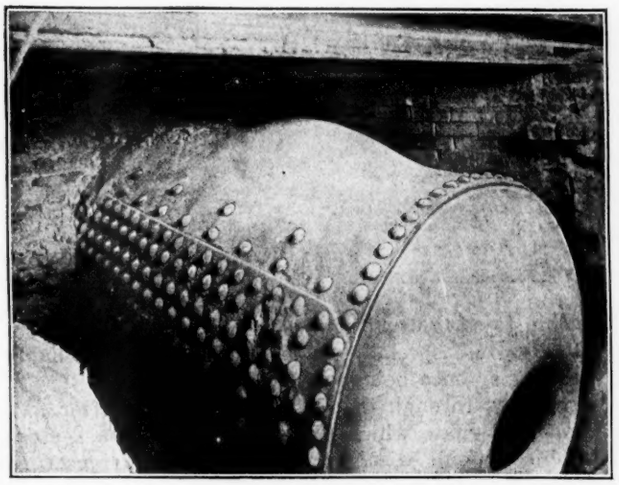
An open-nozzle Diesel will, as a rule, burn a lower-gravity oil than will a closed-nozzle engine.

## An Unusual Boiler Failure

A recent issue of the *Travelers Standard* describes a boiler accident which, fortunately, involved nothing worse than a financial loss, and which carries its own moral.

The boiler, a part of the power plant of a large automobile factory, was of the water-tube type, having 252 tubes 4 in. in diameter and 18 ft. long, and two drums each 48 in. in diameter and 20 ft. long. The steam pressure was 200 lb. Previous to the failure the boiler had been out of service in order to make some maintenance repairs, and after these had been completed it was filled with water for the purpose of a hydrostatic-pressure test. It was impossible to raise the desired pressure within the boiler, however, and the discovery was made that water was running down on the brickwork and between the tubes. Some of the brickwork at the rear of the boiler was removed, and it was found that a bulge 42 in. long, 36 in. wide and 6½ in. deep had developed on the upper shell plate of one of the drums, directly beneath the smoke breeching and that there was an opening about 3 in. long in the plate at the center of the bulge, which is clearly shown in the illustration.

Bulges in boilers are usually caused by accumulations of oil, grease or scale which have been deposited on the interior parts of the boilers directly exposed to the flame and the products of combustion, and which form a non-conducting coating between the heat on one side of the metal plate and the water on the other side. Obviously, it is unlikely that deposits of this



UNUSUAL BULGE IN UPPER SHELL OF BOILER DRUM

nature would have caused the trouble in the present case, and an investigation into the conditions of setting and operation seemed to establish the fact that the damage had been caused by the ignition of a soot deposit on top of the drum, with possibly some shavings, which, having been carried through the chimney by the draft, had then dropped on the drum, adding to the inflammable nature of the deposit, which in due course caught fire, thereby heating the sheet and causing it to expand and rupture because of the internal steam pressure.

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In starting a Diesel, do not overprime the fuel valves. Connecting rods have been bent by fuel oil entering the starting cylinders in large quantities and igniting before top center.

# Safety Regulations for Refrigerating Plants

By G. H. CRAWFORD

THE subject of safety regulations for refrigerating plants is in a very chaotic and unsatisfactory state at the present time. All reputable manufacturers of refrigerating machinery strive to make their product as safe as possible, but there is a great lack of uniformity in construction. The situation is similar to, but far more complicated than, that of steam boilers before the adoption of the A. S. M. E. Code.

Until a short time ago, few cities in the United States had regulations for refrigerating plants, and those only of the most elementary kind; about the only requirement was to provide a safety valve to relieve any excessive pressure in the compressors. The size of valve was not specified. The conservative considered it a great hardship to so protect their own interests by installing such a valve, especially as all such valves are liable to leak after once being opened.

Gradually, through the last few years city after city has adopted rules, which for variety cannot be beaten. The object of all is, of course, to make refrigerating plants more safe. The writers of such codes have usually been familiar with the ammonia compression system. Instead of making separate codes for the different types of plants or omitting for the time the less important ones, inconsistent rules have been inserted concerning absorption machines, carbon dioxide, sulphur dioxide, etc., until even a refrigerating engineer is bewildered in the reading.

At the present time the cities and states shown in the table have adopted codes.

Chicago was about the first large city to regulate cooling plants. Now the Chicago code fills a pamphlet and is by far the most complicated. All plans must be approved by the chief inspector. The Massachusetts code is simple, but includes its own design of safety valve, shown in Fig. 2; it also calls for a special design of diffuser.

The New York regulations cover the situation from the viewpoint of the fire fighter, being administered by the fire commissioner. These regulations were worked out by a committee of the American Society of Refrigerating Engineers in conjunction with the Fire Department. These rules, which were the first to call for ammonia and water mixers for discharging ammonia to the sewer in case of necessity, cover two classes of plants—those above three tons refrigerating capacity and those of less.

Detroit followed the Chicago and New York lead to a great extent. An exceptional feature of the Detroit code is the necessity for approval of plans by the chief inspector. This has led to an absolute prohibition of autogenous welding of pressure vessels in Detroit, the chief inspector of the Department of Safety judging them unsafe.

In Fig. 1 attention is called to the high lights of each code so far as ammonia compression plants are concerned, and it may act as a guide to those who have charge of work in such plants.

The subject of such regulations should be looked at from two points of view—that of safety in operation and that of safety in case of fire or accident. The first thought is of safety valves. Unfortunately, there is yet to be perfected a valve that is consistently tight after it has once been relieved. This means leakage of a costly refrigerant either to the atmosphere or to

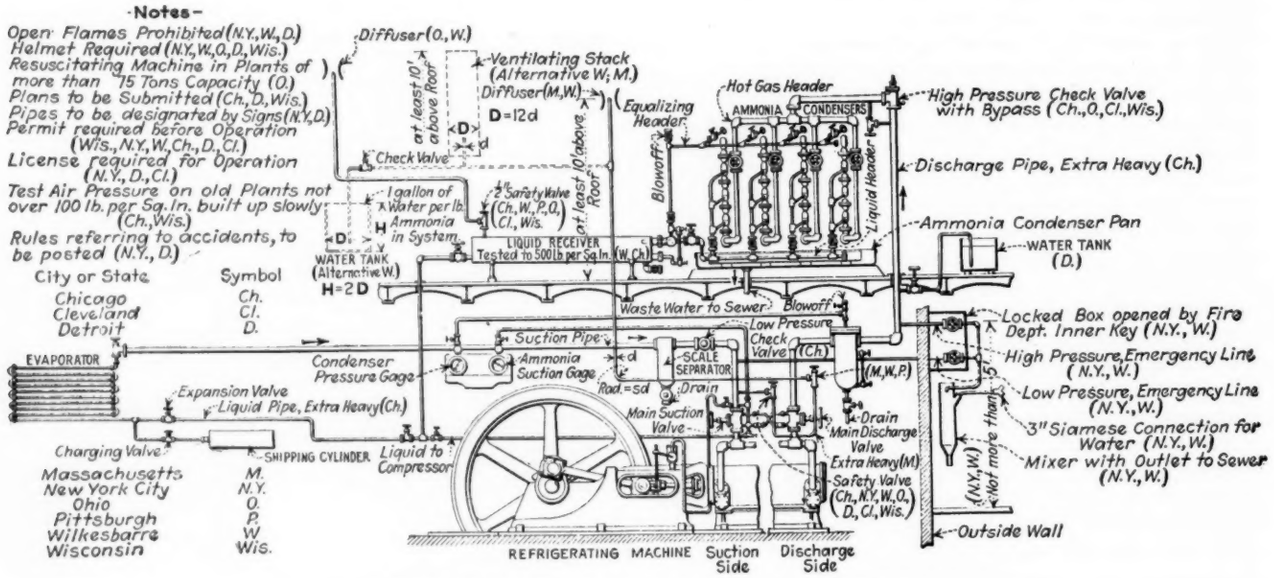



FIG. 1. SAFETY REQUIREMENTS FOR AMMONIA COMPRESSION SYSTEMS

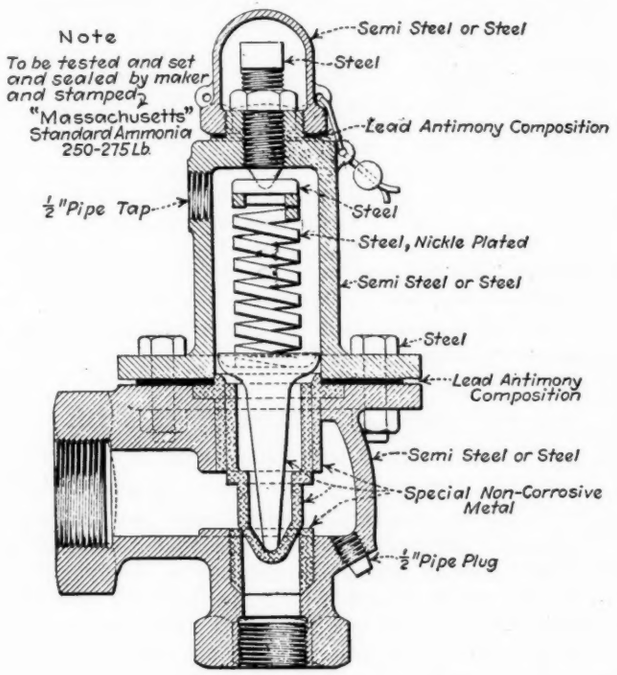
CITIES AND STATES WITH CODES

| City or State | Authority |
|---|---|
| 1. Chicago | Department for the Inspection of Steam Boilers and Steam Plants |
| 2. Cleveland | Division of Smoke Inspection |
| 3. Detroit | Department of Safety Engineering |
| 4. Massachusetts | Board of Rules |
| 5. New York City | Bureau of Fire Prevention |
| 6. Ohio | Industrial Commission of Ohio |
| 7. Pittsburgh | Department of Public Safety |
| 8. Wilkes-Barre, Pa. | Chief Engineer, Fire Department |
| 9. Wisconsin | Industrial Commission of Wisconsin |

the suction side. The former causes a direct financial loss, the latter, indirect through reduced capacity.

The usual location for the inlet of the safety valve is below the main discharge stop valve, the outlet being connected above the main suction stop valve. This allows the compressor to be relieved in case the main discharge stop valve is closed. This arrangement is shown in Fig. 4. Alternate arrangements are shown in Figs. 5, 6 and 7.

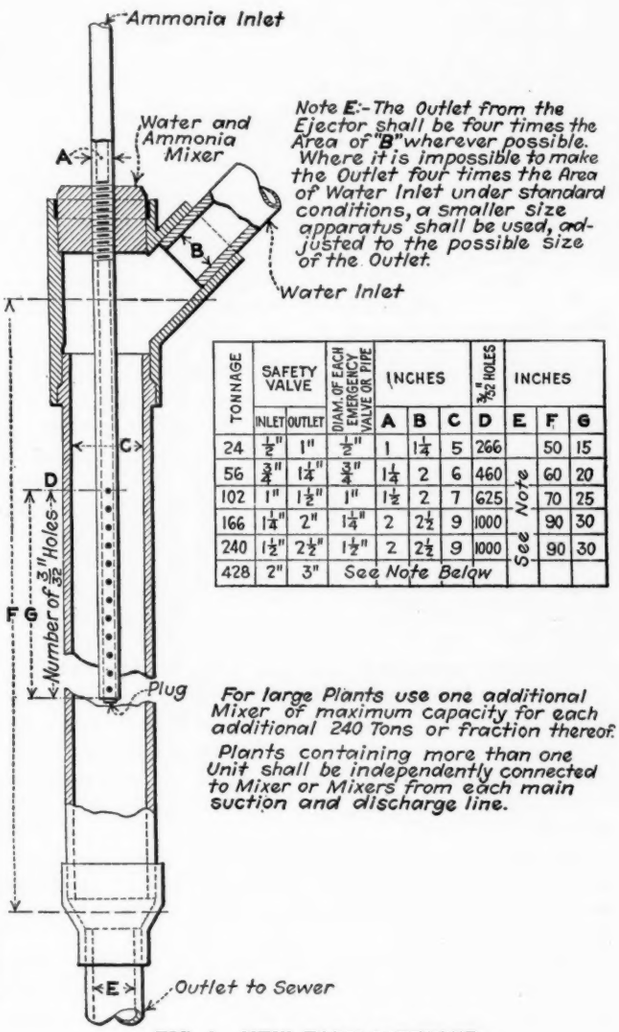
The advantage claimed for the arrangement shown in Fig. 5 is that leakage of the safety valve is unimportant as it simply bypasses the main discharge stop valve. This safety valve can be a check valve if desired. The advantage for the arrangement shown in Fig. 6 is that the valve can be repaired or reground by pumping out




| SIZE OF SAFETY VALVE NOMINAL DIAMETER (INCHES) | | ALLOWABLE DISPLACEMENT (CUBIC FEET) |
|---|---|---|
| Inlet | Discharge | |
| ½" | 1" | 120 |
| ¾" | 1¼" | 280 |
| 1" | 1½" | 510 |
| 1¼" | 2" | 830 |
| 1½" | 2½" | 1200 |
| 2" | 3" | 2120 |

FIG. 2. MASSACHUSETTS SAFETY VALVE

method is the loss of ammonia when the safety valve leaks. Most of the present codes are satisfied with the one safety valve, shown in Fig. 4. However, there are several points equally as important to safeguard as is the compressor. These include the liquid receiver, shell-type condensers and brine coolers, purifiers, etc. Each of these should be protected by a safety valve. Good arguments are advanced that such safety valves should discharge to the suction side. Leakage would then not be of much importance, but if they do discharge into the suction, it is necessary to protect the


Ammonia Inlet
Water and Ammonia Mixer
A
B
Water Inlet
Note E:-The Outlet from the Ejector shall be four times the Area of "B" wherever possible. Where it is impossible to make the Outlet four times the Area of Water Inlet under standard conditions, a smaller size apparatus shall be used, adjusted to the possible size of the Outlet.
C
D
Number of 3/32" Holes
F G
Plug
E
Outlet to Sewer

| TONNAGE | SAFETY VALVE INLET | SAFETY VALVE OUTLET | DIAM. OF EACH EMERGENCY VALVE OR PIPE | INCHES A | B | C | D | 3/32" HOLES | INCHES E | F | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | ½" | 1" | ½" | 1 | 1¼ | 5 | 266 | See Note | | 50 | 15 |
| 56 | ¾" | 1¼" | ¾" | 1¼ | 2 | 6 | 460 | | | 60 | 20 |
| 102 | 1" | 1½" | 1" | 1½ | 2 | 7 | 625 | | | 70 | 25 |
| 166 | 1¼" | 2" | 1¼" | 2 | 2½ | 9 | 1000 | | | 90 | 30 |
| 240 | 1½" | 2½" | 1½" | 2 | 2½ | 9 | 1000 | | | 90 | 30 |
| 428 | 2" | 3" | See Note Below | | | | | | | | |

For large Plants use one additional Mixer of maximum capacity for each additional 240 Tons or fraction thereof.

Plants containing more than one Unit shall be independently connected to Mixer or Mixers from each main suction and discharge line.

FIG. 3. NEW YORK DIFFUSER

the machine and shutting the main stop valves. The danger of using the arrangement in Fig. 6 is as follows: If the compressor was started with both main stop valves shut, the compression of gas would cause the safety valve to operate as a wiredrawing valve. The discharge gas at a comparatively high temperature would pass back to the suction at low pressure and would again be compressed. This would cause an extremely rapid and progressive rise in temperature. The absolute temperature at the end of compression is proportioned to the absolute temperature at the start of compression. The rise in temperature would in turn cause a dangerous rise in pressure.

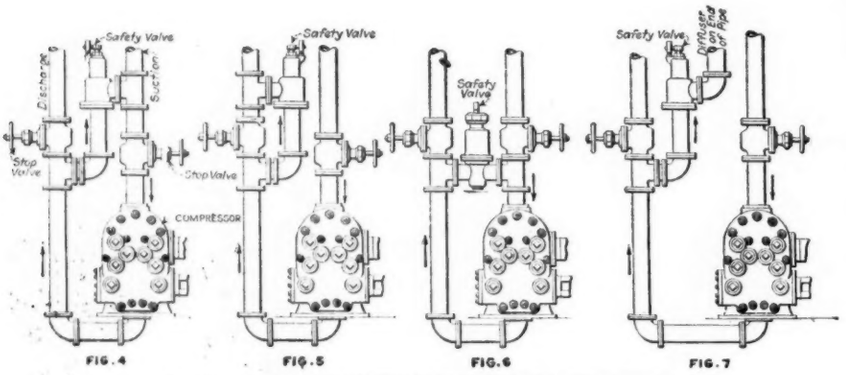
Fig. 7 shows the Massachusetts code method of connecting the safety valve. The only objection to this

suction by at least one safety valve to the atmosphere. If this latter valve is set at a reasonable figure, say 200 lb. per sq.in., to allow for shutdown in hot weather, then the other valves will not relieve until the pressure under their disks is 200 lb. plus their relieving pressure. Thus the pressure in a vessel in the high-pressure side might be as high as 450 lb. per sq.in. before it was relieved by a safety valve that was set for 250 lb.

In addition to safety valves it is possible to protect electrically driven plants by pressure-operated cutouts. These have not been recognized in the codes, but are sometimes passed by the inspectors as alternatives. Several codes prohibit open lights or flames in compressor rooms. The escaping gas, if mixed with the

proper amount of air, will explode on meeting an open flame and cause fire and other damage. For this reason open lights and flames should be avoided, and high-tension electrical lines should be thoroughly insulated in the vicinity of ammonia compressors.

From the viewpoint of the firemen, in case of fire in a refrigerating plant some means should be made to get rid of the ammonia charge. In New York, Detroit and Wilkesbarre this is done by emergency pipes controlled by valves outside the plant. These pipes lead either (1) to water in a tank, (2) to the atmosphere above adjacent buildings or (3) to a water and ammonia mixer discharging to the sewer, Fig. 3. The success of these arrangements has not been sufficiently established to warrant a recommendation of adoption.




FIGS. 4 TO 7. SAFETY-VALVE ARRANGEMENTS

An unnecessary hazard in most plants is the arrangement of the connection for charging in fresh ammonia. Usually, the shipping cylinder is connected to the liquid line. To charge in liquid, it is necessary to shut the main liquid valve and open the valve on the shipping cylinder. If the operator should forget to close the main liquid valve, and the head pressure is high or the shipping cylinder cold—as it usually is—liquid will flow into the cylinder instead of out of it. If the operator should shut the valve on the shipping cylinder, the cylinder would be full of liquid. This liquid, if heated a few degrees, would burst the cylinder with disastrous results. The proper location for the charging connection is on the low-pressure side of the expansion valve.

The Chicago and Wisconsin codes are the only ones that recognize the danger of a high air-pressure test on old plants. A limit of 100 lb. per sq.in. pressure is set for old plants, owing to the danger of an explosion. This is a wise regulation and it should be incorporated in other codes.

As in other plants, safety is largely in the hands of the operator. For this reason and for reasons of economy of operation refrigerating plants should be under the charge of licensed engineers. No one thing will help to improve conditions more than a good license law.

The American Society of Refrigerating Engineers has realized fully the disadvantages of the many different codes. Considerable confusion exists because of the variety of the rules, and yet, on account of the complexity of the task, it has not been possible to perfect a code to cover all the types of refrigerating plants. In 1919 a "tentative code" was published by the A. S. R. E. This combined the good points of all the codes and, though imperfect, was greatly superior to any of those adopted prior to that time. So far, however, the tentative code has been adopted only by Wilkesbarre, Pa. It was printed in *Power* for June 17, 1919.

At the present time a committee of the A. S. R. E. is bringing to completion a final revision of the code. This will be far in advance of the existing regulations. It is to be hoped that this will be adopted by the leading cities in the near future as an example to all. Such action will mark a great step in advance for the industry of refrigeration.

The committee should take steps in the preparation of the code to differentiate between the several refrigeration mediums and provide a code applicable to each system. The advent of the small household refrigeration system requires a code covering the necessary safety devices.

Since there exists, in some localities, a decided objection to autogenous welding the A. S. R. E. should investigate welding processes and decide once for all if such welding is safe in a refrigeration plant. If results are satisfactory, the safety code should permit the use of autogenous welded pressure wheels.

## Germany Still Struggling With the Coal Problem

In the Dec. 7, 1920, issue of *Power* there appeared an article on the nationalization of the coal mines of Germany. Reports received since that time indicate that the faction headed by Stinnes is slowly gaining over the other groups which are working toward a solution of the problem. Stinnes is a German capitalist who has tremendous holdings in industrial projects and is politically very powerful. The plan that he and his followers are striving to realize is for co-operative trusts of related industries, such as coal mines and iron and steel works; these combines would be controlled by boards in which the consumers would have the majority.

A subcommittee composed of Stinnes and two other mine owners has been holding a conference in Essen, the heart of the western mining district, to consider industrial problems. The result of this conference appears to be that the two opposing groups, one favoring government ownership, the other favoring co-operative trusts, have arrived at the understanding that the most complete and economical utilization of all industrial products in the interest of the whole nation must be secured at all costs. The outcome of this understanding will, in the opinion of many, be the adoption of Stinnes' plan.

Another proposal, however, which has recently been introduced into the discussion, provides for socialization of the mining land only, while the mines shall remain as before, in private hands. While numerous objections to the proposition are being advanced, the fact that it is essentially a compromise may lead to its adoption.

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**In rebabbitting bearings don't use the shaft for a mandrel. Run the bearing smaller in diameter than the shaft and bore to size.**

# A Simple Brake-Test Apparatus

By Julian C. Smallwood*

Having had occasion recently to make some commercial tests of a small marine gasoline engine of special design, covering capacity and fuel consumption, the writer devised the apparatus here described.

A variable-speed gasoline engine cannot be tested satisfactorily with the ordinary prony brake with wooden blocks for friction surfaces, because the friction of these surfaces and consequently the delivered horsepower vary widely. When the usual form of prony brake is applied to such an engine, it is necessary to give very close hand regulation to the brake-band tension to prevent the engine momentarily overspeeding or underspeeding, with the always-present possibility of sudden stoppage.

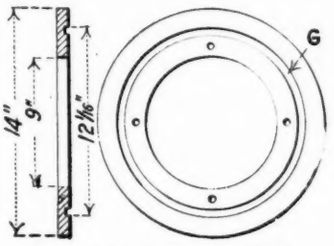


FIG. 1. SHOWING FLANGE PATTERN

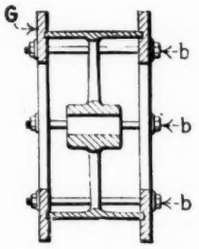


FIG. 2. FLANGES ASSEMBLED

To avoid these difficulties without too much expense, a compensating rope brake was decided upon; that is, a brake that automatically relieves the band tension when the brake friction increases, and vice versa. The rope type of brake was adopted because the friction surfaces are smoother and there is less tendency to chatter than with wood blocks; furthermore, there is practically no expense in its construction except that for the rope.

A water-cooled brake pulley was necessary to prevent burning of the rope. For this purpose a stock cast-iron pulley was bought, 12 in. in diameter and 4-in. straight face. A pattern was then made for two flanges, as in Fig. 1, and grooves $G$ were cut in the castings, which were then assembled on the pulley as shown in Fig. 2, by means of the bolts $b$, $b$. In this way a pulley with internal and external flanges was built up at a considerably less expense than would have been required for casting such a pulley solid.

As the internal flanges held the cooling water in contact with the pulley rim, the joint at $G$, Fig. 2, had to be made tight against the centrifugal force urging the water through this joint. This was accomplished by the use of a paper gasket in the groove.

One advantage of this form of pulley lies in the fact that the rim is free to expand (through heating), since the groove is made a little larger than the side face of the rim. In operation, a stream of water was run continuously into the inside of the pulley, at a rate as nearly as possible equal to that at which it boiled away.

The brake rope was one-half inch cotton sash cord and was assembled with the necessary apparatus as shown in Fig. 3. Two turns of a double strand were taken about the pulley. A small weight pan and weights $w$ of about 2 lb., on the lower end of the rope produced a tension of about 45 lb. on the spring scales $S$ above, the difference between these forces (with corrections later mentioned) being the net force resisting the turning effort of the engine.

This combination alone is unsatisfactory, since the friction between rope and pulley will increase, necessitating close hand regulation. To get automatic regulation (that is, to make the brake "compensating"), the small letter scales $s$, Fig. 3, was placed beneath the weight pan shown in the illustration. The result is as follows:

Suppose that there is enough weight on the weight pan to produce the desired pull on the upper rope and that the weight pan clears the weighing surface of the lower scales by about $\frac{1}{8}$ in. Further, suppose that the friction between rope and wheel increases. This will cause a greater pull on the upper part of the rope, pulling it down enough so that the weight pan $w$ bears upon the lower scales $s$. Immediately this relieves the tension on the lower end of the rope, resulting in a much greater reduction in tension on the upper end of the rope and in the pull on the upper scales. Thus any increase in friction between rope and brake is compensated by relieving the tension on the lower end of the rope, and the brake effort remains very nearly constant.

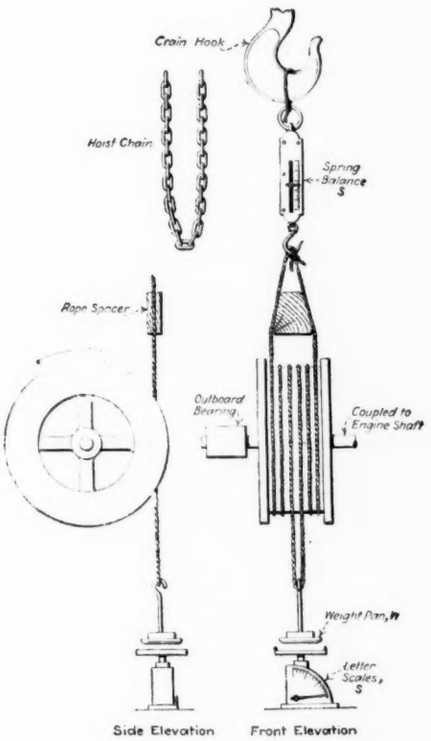


FIG. 3. ASSEMBLY OF BRAKE

Additional frictional effort may be secured by placing more weights on the weight pan $w$ and by raising the upper scales $S$. It was found very convenient to support the upper scales from the hook of a traveling crane (fortunately available). By manipulating the hoist chain of the crane occasionally during a test run on the engine, the brake load could be kept as constant as it could be read on the scales.

*Associate Professor of Mechanical Engineering, Johns Hopkins University.

The effective brake pull equals reading of $S$ + reading of $s$ — weight $w$ — weight of spacer block and excess of rope above center line of pulley.

This pull acts on a moment arm equal to the radius of the pulley plus one-half the diameter of the rope.

It may be noted, too, that since the pulley weighed about 50 lb., the effect of the brake pull was to relieve the reaction on the outboard bearing.

It was found that the engine could be run without damage to the rope (the rope was thoroughly wetted at the beginning of each run), at speeds between 600 and 800 r.p.m., and it was unnecessary at any time to shut down because of limitations of the testing apparatus.

## An Emergency Three-Phase to Two-Phase Connection

By J. B. Gibbs

The connection shown in Fig. 1 has been suggested as a way to get power for a two-phase motor from a three-phase 4,400-volt four-wire line, and it is of interest to see what the result will be. Fig. 2 shows a schematic diagram of the connection, and Fig. 3 shows the corresponding vector diagram. The letters in all three figures indicate corresponding points. *A*, *B* and *C* are standard distributing transformers having two secondary windings which can be connected in series for 460 volts or in parallel for 230 volts, and having a 2,300-volt primary winding with two 5 per cent taps. The figures show that the full primary winding of transformer *A* is connected between one of the three-phase lines and the neutral, while its secondary windings are connected in series and supply one phase of the two-phase circuit. The primary windings of transformers *B* and *C* are connected on their 5 per cent taps between the neutral and the other two lines, while their secondary windings are connected in parallel. The secondary circuits of these

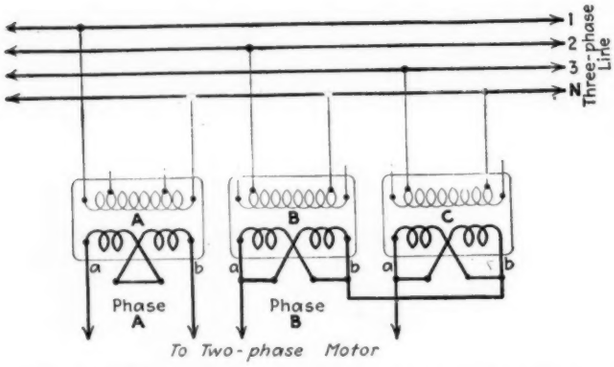


FIG. 1. THREE-PHASE TO TWO-PHASE TRANSFORMATION WITH THREE STANDARD TRANSFORMERS.

two transformers are then connected in series to supply the other phase of the two-phase circuit.

In standard distributing transformers 2,300 volts on the full primary winding will give 230 volts on the secondary, when connected as shown for transformers *B* and *C;* therefore, 2,300 volts on 90 per cent of the primary winding will give $\frac{230}{0.90} = 255.5$ volts on the secondary. But the two secondary voltages are 120 deg. apart, and their resultant will be $255.5 \times 2 \times \cos 30$ deg. = 442.5 volts, at right angles to the secondary voltage of the transformer *A*. The secondary voltage of transformer *A*, however, will be $\frac{2,300}{5} = 460$ volts, so there will be an unbalance of 17.5 volts, or about 4 per cent between the two voltages. A two-phase motor will operate fairly well under these conditions, but will reach its

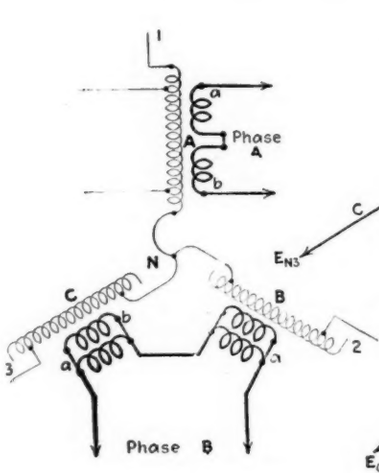


FIG. 2. SCHEMATIC DIAGRAM OF CONNECTION FIG. 1

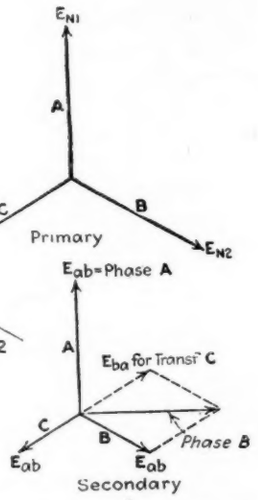


FIG. 3. VOLTAGE RELATIONS OF CONNECTION FIG. 1

normal full-load temperature when carrying something less than full load.

It should be noted that the foregoing is based on the assumption that the three-phase circuit is four-wire and that the neutral is connected to the neutral of the generator. If this is not the case, an entirely different condition exists in the transformers. The current that flows in the primary of transformer *A* must then divide and return through the primaries of transformers *B* and *C*. There is no component of the load current of *B* and *C* in the proper phase position to balance this current from *A*, and *B* and *C* are, of course, on separate cores; therefore this current from *A* tends to build up flux in the cores of transformers *B* and *C*, and these will act the same as high impedances in series with transformer *A* and will consume a large part of the voltage that would normally be applied to *A*. The heavier the load on *A* the larger this drop will be. The result will be a large unbalance in the secondary voltages, and in some cases the increased voltage on transformers *B* and *C* may be sufficient to cause overheating from exciting current. This connection should never be used unless the neutral point can be connected to the neutral of the generator, in which case the current in the primary of transformer *A*, instead of having to flow through the high impedance of *B* and *C*, returns through the neutral wire.

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The exhaust valves of a Diesel engine should be removed and reground at least once in four months. A regular schedule should be carried out, removing a valve each week. If the exhaust-valve stem sticks in the cage, injections of kerosene will cut the gum. It is a good habit to use a little kerosene each day. If the oil is heavy, the gumming is very heavy.

# EDITORIALS

## Power-Industry Outlook Encouraging

A LARGE portion of this issue is devoted to a review of the power-industry activities of the last year. Departing from the practice of previous years, when the editorial staff prepared the review, this year it has for the most part been written by engineers that are specialists in certain particular branches of the industry. At this time, when there is a general business depression and a feeling of uncertainty among business men, it is encouraging to read this review, since not one of the twenty-one contributors expresses a pessimistic outlook for the future. Although the year just past has been devoted largely to a recovery from the effects of the war and no epoch-making engineering development work has been done, nevertheless on the whole a great deal has been accomplished that will have a marked influence on power-engineering practice in years to come.

Notable among the events of the last twelve months was the passage of the Federal Water-Power Act, which after ten years' discussion has established a definite policy toward national water-power development. The impetus that the passage of this act will give water-power development is evidenced by the filing of one-hundred and twenty-five applications involving more than ten-million horsepower of water power, during the six months since the act was passed.

Another undertaking, initiated during the past year, that undoubtedly will influence our national power policy is the Superpower Survey of the Northeastern Seaboard. Heretofore large power systems have in the main just grown, although they were governed by what best engineering practice dictated at the time of each extension. In the superpower survey we have a broad engineering study of the power requirements of an extensive industrial district that has outgrown the present methods of power distribution. It is too early to record the results of this survey, but it will undoubtedly have a far-reaching influence on power engineering of the future. Instead of a hit-or-miss policy of plant location and power-system interconnection, as in the past, there has been established a national power-engineering policy that has the possibilities of a vast economic influence.

At the beginning of 1920 fuel oil was looming on the horizon as a possible economic source of fuel for power plants. As a result a number of coal-burning plants changed over to oil burning. However, before this movement was well under way the price of oil jumped to undreamed-of heights, and this, along with the difficulty experienced in obtaining oil, has arrested development in this direction. It is doubtful if the future will see another movement toward the general use of oil for fuel in power plants, although it will play an important rôle in marine work.

The coal situation has cleared up very little during the year 1920. O. P. Hood in this issue very aptly sizes up the past year's experience in the coal industry when he says: "The days of 1920 have been filled with fuel troubles for the miner, operator, transporter, dealer and user, with a considerable accent on the user." However, the Federal Government is beginning to take a hand and the prospects for 1921 look somewhat brighter. But it is evident that the days of an abundance of high-grade coal at low prices are past. With this thought in mind considerable attention is being given to the burning of low-grade coal in powdered form, and the development during the last few months looks encouraging.

For a number of years past interest has been centered in the safety-first movement. The reports, published in this issue, by S. F. Jeter and Sidney J. Williams, two engineers closely allied with this work, indicate that this movement has borne fruit, and last year showed a marked decrease in industrial accidents.

Whatever misgiving this country may hold for the future, as it enters upon another year, taking the review of the power industry as published in this issue as a whole, it is evident that the engineers of this industry are full of hope and have no apprehensions.

## Collusion in Coal Reports?

IN THE investigation by the United States Senate committee of coal prices and coal-supply conditions it has been freely charged that many scandalous proceedings have contributed to the faulty functioning of our fuel-supply industry and the excessive prices that have prevailed. One of the charges against the Government officials responsible for collection of coal-production reports would be particularly distressing to all engineers if the basis for refuting the charge were not so obvious and unquestionable. The case in mind is the charge that the United States Geological Survey has deliberately suppressed facts with respect to coal production in certain fields at the request of the operators of these districts. The facts are as follows:

The Geological Survey's weekly coal-production reports gave the output of Illinois mines in such a form as not to permit the user to distinguish between the output of one district and that of certain others. At the request of certain coal men the Survey decided to divide the report showing the several fields separately, thus facilitating use of these data. When the new basis of report was undertaken, certain coal operators, through one of the local associations, refused to continue any reports to the Survey unless the figures were combined to obscure the facts with regard to their particular districts. They are even charged with having specifically stated in correspondence that they were perfectly willing to turn in figures for their district only provided the public did not learn how favorable the car supply in their territory was and thereby be enabled to compel them more nearly to live up to their contract coal obligations. In other words, it appears to be demonstrated that the operators of this particular district sought by obscuring the facts to continue sale of a larger part of their coal in the spot market (and

for very favorable prices than would have been possible if those with whom they had contracts knew how favorably they were situated with respect to an adequate car supply.

The Geological Survey in these circumstances was virtually helpless, for it was dependent solely upon voluntary reports from this district. If the operators refused to report on any nominal ground whatsoever, even on the ground that it was simply too much trouble, the Survey had no recourse by which to compel co-operation. It is not strange, therefore, that the Survey preferred to have the facts even with the restriction that permitted only report for the state as a whole, rather than to insist upon publicity by districts and incidentally thereby to cut off all sources of information from these parts of the state and make their data very incomplete in important territory.

To moralize upon this particular phase of the coal situation would be easy. One might say this is ample demonstration that the Government must have and maintain an agency which has the authority to compel reports. Another might insist on indictment and prosecution of these particular operators or their local association. Still others would have their own idea of a "cure-all" for the situation. In one respect we believe all fair-minded persons will agree—that this is simply another example where an effort is being made to defend a culprit by counter charges against the accuser and thus befog the issue.

## Fools and Their Money

THERE are some things that we don't understand. That sounds a trifle conceited, doesn't it? But we don't mean it that way. Of course there are lots of things we don't understand—the way of a maid with a man, who is the man higher up, how to live on an editor's salary, and things like that, if you know what we mean, things we don't understand and never expect to understand; and yet once in a while there's a ray of hope, a more or less lucid interval in which a gleam of almost human intelligence seems (only *seems*, mind you) to penetrate the gloom.

But there are things worse than those; Oh, much worse! Things we don't understand and never expect to understand and that never have a ray or a gleam or—anything.

In the two last preceding issues appeared descriptions of perpetual-motion devices, both of them schemes worked out with more or less elaboration to accomplish the time-honored end of getting something for nothing; primarily, of course, through selling stock to the gullible public.

Now then, what we don't understand—and don't believe you do either—is how, year after year, in season and out of season, apparently sane people will hand over their presumably hard-earned dollars in exchange for little scraps of paper not worth their weight even for kindling.

We cheerfully confess to the pleasurable excitement of backing the right (?) horse, or yacht, or a "champeen" to the imminent danger of our bank roll or pocket contents, or even of taking a sporting chance on a "straight" game, or the cubes or the merry little wheel, but the "heads-I-win, tails-you-lose" plan of investment is beyond comprehension.

There are two kinds of "investors," and of the promoters who exploit them; those who through ignorance or crackle-headedness actually believe the pot of gold at the rainbow's end is just over the next hill and almost within their grasp, and those who deliberately use the hidden-spring or concealed-wire method of obtaining results impossible of accomplishment by more prosaic but honest means.

The dupes, investors, suckers—whatever you choose to call them—are, however, all of a kind; the only difference is in the length of the dream.

All of which brings us to the moral and clinch of our discourse and New Year's peroration. Let us resolve, like good citizens and honest engineers, not to limit our contemplation of fakers and get-rich-quick artists to a cynical smile and contemptuous snicker, but to warn our lay brothers as opportunity offers, of the danger that lurks behind the "frictionless wheel" and the "gravity-defying lever."

The columns of *Power* are always open for the showing up of swindlers and charlatans regardless of "capitalization" and alleged engineering qualifications of the promoters.

## Criminal Negligence Vs Natural Resources

THE phrase "criminal negligence" is not a pretty one, but it is decidedly expressive and unfortunately very apropos of the way we as a nation have squandered our natural resources. It is unnecessary to go into details as we all know the story. Our forests, our wild game, our fisheries, our fuel have all dwindled away, and at last we are waking up to the fact that, unlike the purse of Fortunatus, they will not serve us indefinitely. Legislation is needed; not of the "tinkering," but of the truly constructive type.

The first logical step toward an intelligent formation of the remedial measures is a full understanding of the resources involved and the steps that have led up to present conditions. Fortunately, reliable data and statistics are available for this purpose, and the statement of Mr. Smith, Chief of the United States Geological Survey, appearing in this issue, comes at an opportune moment. It is replete with facts and figures and will make a good foundation for sober thought anent the present fuel situation.

## Refrigeration Safety Regulations

IN AN article appearing in this issue of *Power* attention is called to the chaotic condition of safety regulations for refrigerating plants. There is a serious hazard in all industrial apparatus containing volatile liquids under pressure. This is especially true in refrigerating plants. Yet in spite of this danger comparatively few of our cities have safety codes covering cooling machinery and apparatus and among those that have there is wide discrepancy in many important points of design and installation.

It is gratifying to know that the American Society of Refrigerating Engineers has nearly completed a final revision of its tentative code. In the meantime individual plant owners will do well to study the question as outlined in the article referred to, and to take the necessary steps to protect their employees and plants in advance of legislation.

# CORRESPONDENCE

## Reducing-Valve Troubles

In many steam plants steam at different pressures is used for various purposes, such as heating the building, for the machines and for the conditioning of materials for manufacture. Generally, this steam comes from the boiler at a high pressure and is reduced in passing through a valve that is throttled by the action of a lower steam pressure on a diaphragm of larger area than the steam valve itself, which is opened by the movement of a weighted lever or by other means. Fig. 1 is a cross-sectional view of a reducing valve having a large diaphragm *A* and weighted lever *B*. *C C* are the steam valve discs. This valve is double-ported and is shown closed. The lower pressure in the pipe *D* overcomes the steam pressure on the discs *C C* and the weight *B* together with the pressure on the diaphragm *A*, which closes the valve. The amount of pressure desired on the outlet side is changeable by moving the weight outward for more pressure or inward for less pressure. Some very large valves have two weighted levers or the lever may be compounded.

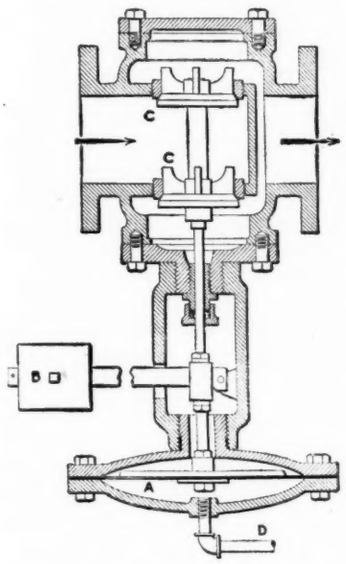



FIG. 1. REDUCING VALVE WITH RUBBER DIAPHRAGM

This type of valve, as well as many others, I have found to be a sort of menace to a heating system where cast-iron radiators are used. These radiators are tested for only 50 lb. steam pressure and are supposed to withstand but 25 lb. in service at the most. Should the rubber diaphragm *A* crack and allow the pressure beneath it to lower, the weight *B* will drop and bring the steam valve to full opening, thus putting boiler pressure on the radiators; in some cases they have burst. In one instance I saw a pressure of 90 lb. on cast-iron radiators. The steam was shut off and a broken diaphragm was found in the reducing valve. A slight water hammer in the pipe may finish an old diaphragm and throw full pressure on the radiators.

To overcome this menace in one plant, they installed a double-ported piston valve, Fig. 2, which was designed with a lever weight *E* to close it. This valve was opened by a damper regulator, *F* being the water-pressure cylinder. Weights were placed at *G* or *H* to get the desired pressure on the system.

It was necessary to have the weight *E* heavy enough to close the valve *J*, and weights on the piston rod of the damper regulator, as at *K*, opened the valve.

The regulator has a leather-cup piston packing in the cylinder, which has to be renewed, and also a rubber diaphragm, besides the main valve of the regulator, which has to be renewed about every two years. I make it a point to renew the rubber diaphragms every year at the beginning of the heating season, or every six months if used daily during the whole year.

The reducing valve, having a composition or copper diaphragm, needs to have the diaphragms examined

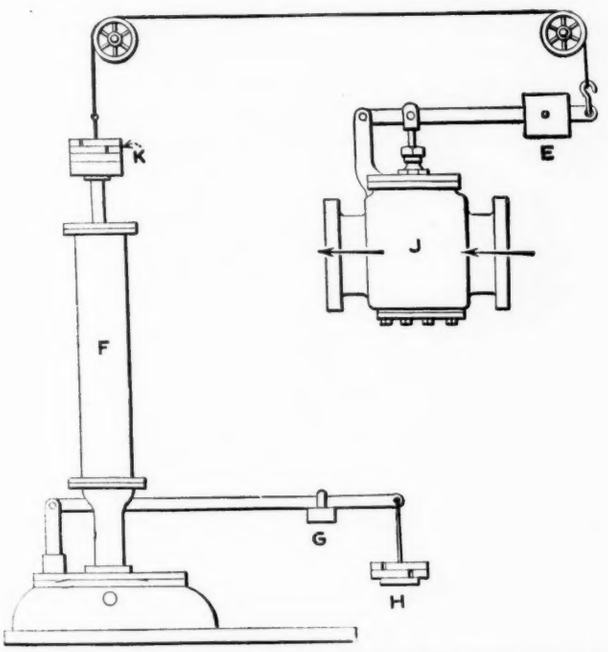



FIG. 2. DOUBLE-PORTED PISTON VALVE OPERATED BY A DAMPER REGULATOR

and the springs and the small passages cleaned out, as scale from the pipe as well as bits of packing and composition valve discs will collect in them and prevent their working properly. All reducing valves should have the main steam-valve disc and seat ground in, as

they become worn or cut and leak badly, thus putting a greater steam pressure on the line than that for which the valve is set.

Screwing down on the wheel *M*, Fig. 3, puts more pressure on the outlet side, and turning it back reduces the pressure on the outlet side, just as moving the weight back and forth on the lever, Fig. 2, increases or decreases the pressure. The spring of the type of reducing valve, Fig. 3, will become weak from a constant high steam temperature and should be replaced by new ones, for although the valve may apparently be all right, the springs compress too easily and do not allow the interior small valves to operate. *L L* are stop valves, and *N* is the bypass valve to be used in case the diaphragm should give out or the reducing valve should not pass steam.

This type is the only reducing valve that I have found that will shut off the steam in case the metal diaphragm should break. This is because the diaphragm has to move one way against a spring and the other against a small valve which admits steam to balance or unbalance the main valve and aid the diaphragm.

The piping of the reducing valve shown in Figs. 1 and 2 are frequently arranged as shown in Fig. 3, with the bypass the same size as the inlet pipe to the reducing valve. In such cases the piping on the outlet side is such as can withstand full boiler pressure, and frequently full pressure is required, at which time the reducing valve can be shut off. Where full boiler pressure is not safe, a bypass pipe of smaller diameter is preferable to throttling a full-sized valve. The bypass, Fig. 3, is ¾-in. pipe. If the valve *N* were left wide open, it would hardly be possible to get an overpressure on the far end of the heating line, owing to the reduced size of the pipe, as doubling the diameter increases the capacity four times. So decreasing it the same amount would decrease the capacity three-quarters, leaving one-quarter still in service.

In spite of this fact we see, daily, reducing systems with cast-iron radiators with full-sized bypass pipes

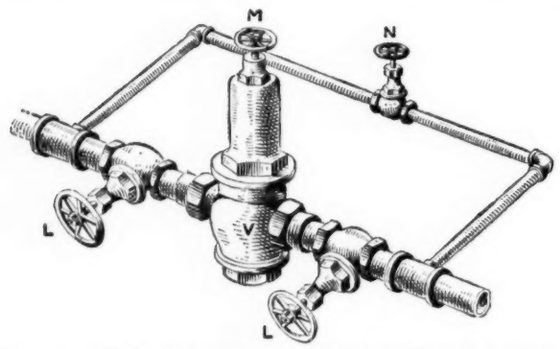



FIG. 3. REDUCING VALVE AND BYPASS IN HEATING SYSTEM PIPING

and valves which depend on the warning of a miniature safety valve and on the constant vigilance of the engineer to prevent an overpressure building up on the radiators.

It would appear that reducing valves should be made a trifle more "foolproof" or the proper safe reliable valves should be more extensively used. More laws may be needed to protect the general public, who at present are depending on the engineer's vigilance for safety.

R. A. CULTRA.

Cambridge, Mass.

## Why Does a Leaky Compressor Valve Get Hot?

Answering Donald McFee's inquiry in the Nov. 16 issue of *Power*, page 795, first let us consider the events that take place in one end of the air cylinder for one revolution of the compressor with all valves tight.

With the piston going from the head end to the crank end, the inlet valve is open, allowing the cylinder to fill with air to be compressed upon the return stroke; when the piston reaches the crank-end center, the inlet valve

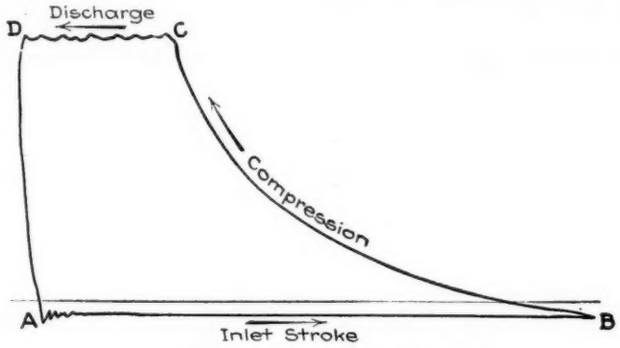



DIAGRAM FROM AIR CYLINDER

closes. The piston, returning, starts compressing until the air has reached a pressure enough greater than the discharge-line pressure to overcome the tension of the springs on the back of the poppet discharge valves and forces them open, allowing the compressed air to escape from the cylinder during such part of the compression stroke as lies between the points *C* and *D* of the accompanying air-cylinder indicator diagram.

It will be seen that with normal operation there is a flow of air through the discharge valves for only a small part of the revolution, thus giving the jacket water a chance to cool off the valves and head before the next slug of hot air.

If a discharge valve is leaking, there will be a return flow whenever the pressure within the cylinder is less than the discharge-line pressure, or from the point *A* to *C*. This nearly constant flow of more or less air, depending on the extent of the leak, imposes more work upon the jacket water at this point, thus allowing the metal to become hotter.

A bad leak, such as would be caused by a broken valve or a valve stuck open would, if a second-stage valve, show by a rise in the intercooler pressure, which might be great enough to pop the relief valve while the piston was going from the end having the leaky valve.

If a first-stage discharge valve was broken or stuck open, it would be accompanied by a drop in intercooler pressure, particularly while the piston was going from the end having the leaky valve. Needless to say, leaky valves will greatly diminish the capacity of a compressor.

Another source of trouble is leaky tubes and leaky tube packing in the intercooler and in the aftercooler.

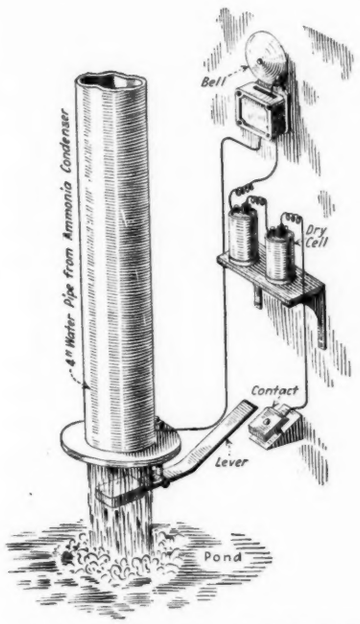
If the end of the jacket water discharge piping can be seen, it gives one a good check on the leaks, but it does not show whether the intercooler, aftercooler or cylinder jackets are leaking when the several discharges are tied together. This could be determined by shutting down, disconnecting the piping and testing individually each with air.

JOHN A. MURDOCK.

Medford, Mass.

## Alarm Signal for Pump

In the plant where I am employed there are two ammonia compressors, each of 20 tons' capacity. Water is pumped from a well with a duplex pump to the top of the building through a double-pipe condenser, the water leaving the condenser by a 4-in. pipe down the side of the building into a pond. Trouble has been caused several times by the pump stopping, owing to the crosshead getting loose on the piston rod, the pump being in an out-of-the-way place and no alarm to notify us. The pressure went to a dangerous point on one occasion and caused ammonia leaks in some of the joints. As the engineers had to spend considerable of their time in an adjoining engine room they were unable to watch the pressure on the compressor and I finally figured out a way that the men would be notified whenever the pump stopped.



ALARM RINGS WHEN PUMP STOPS

The sketch shows the arrangement devised, which has proved satisfactory. I put a flange on the bottom of the 4-in. water pipe emptying into the pond and attached a lever with a paddle on one end for the water to fall against. A contact was placed on the side of the building and a bell installed in the turbine room near the switchboard with two dry cells in the circuit.

Just as long as the pump continues running the water strikes the paddle and holds the lever away from the contact, but the minute the pump stops the flow of water ceases and the other end of the lever falls on the contact and causes the bell to ring. This warns the engineer before the condenser pressure has had time to rise and gives him time to stop the compressor or get the pump started again before any serious damage is done.

G. M. GROVE.

Clifton Forge, Va.

## Where Did the Oil Go?

On Aug. 25, 1920, I took charge of a power plant equipped with three horizontal-tubular boilers, two of which are under consideration in this article. I found in the chief engineer's desk a boiler inspector's report on boiler No. 2, dated July 17, part of which read: "Medium deposit of oil on the shell and tubes."

It was suggested that the boiling-out process be used to eliminate these deposits. On Sept. 27 No. 1 boiler was inspected and the report was comparatively the same as for No. 2. The material for boiling out these two boilers was not supplied until Nov. 8. On the following day No. 2 boiler was drained and opened for the purpose of ascertaining the condition of the tubes and shell so that we could check the results of boiling-out. To my surprise there was no oil on either the tubes or shell and very little loose or attached scale. The following week No. 1 boiler was opened and the same absence of oil and scale was found as in No. 2 boiler.

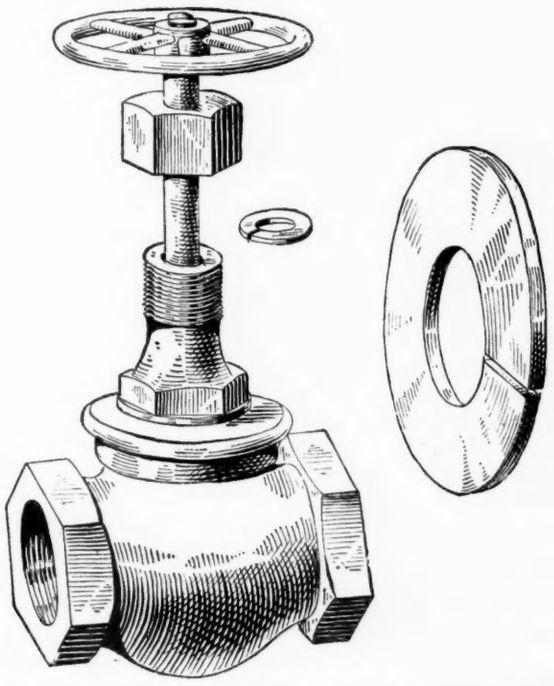
The tubes and shell of this boiler, when open on Sept. 27, I know from personal observation, were coated with oil, but this was gone on Nov. 16. No compound had been used in these boilers, and the operating conditions were the same as for the past year. Where did the oil go? Perhaps some reader has had a similar experience. If so, an account of the occurrence would probably be of interest to other engineers.

New York City. A. K. VRADENBURGH.

## Valve-Stem Packing Rings

At different times I have read in engineering magazines articles on packing for valve stems, but I have never seen the method we use mentioned. Rings to give the valve stem and stuffing box a good fit are cut with a gasket cutter from $\frac{1}{16}$- or $\frac{1}{8}$-in. sheet packing. Also, scrap pieces, if large enough, can be used. After the rings are made, one side is cut open to permit slipping on the valve stem.

Valves of any size above 2 in. may be packed in this way. On high-pressure valves we use a good grade of packing; on low-pressure valves a poorer grade. I have known valve stems so packed to remain tight for fifteen years under high steam pressure and give no trouble.


VALVE-STEM PACKING RING AND ITS APPLICATION

I have used the rings in rising and non-rising stem valves with good results and find this way of packing ends valve-stem packing trouble, which is a great annoyance at times.

THOMAS J. PASCOE.

Norway, Mich.

## Treatment of Direct-Current Motors

In the Oct. 12 issue of *Power* Mr. Arnold contributed an excellent article on "The Treatment of Direct-Current Motors for Mining Conditions." The advice given as regards frequent inspection and cleaning and the method of drying out and impregnating the windings with insulating compound once a year is good and, if adopted in all industrial plants, would prevent to a large extent the breakdown of motors through failure of the insulation. He advises the use of a linseed-oil varnish for dipping and baking purposes, claiming that it will not dry out hard, retains its flexibility after exposure to heat and is not affected by oils or water. If the compound he uses has all those good features and in addition does not affect the copper of the windings chemically, it is an ideal insulating varnish. Unfortunately, a great many of the paints and varnishes on the market today, and used indiscriminately in repair shops, are entirely unsuitable as a permanent protection for the windings of electrical machines under service conditions. They may have all the good qualities cited when first applied, but they do not retain them long. Some of them slowly dry up and crack, thereby presenting innumerable fissures where moisture can enter. Others are affected by lubricating oil in such a manner as to liberate acids which cause copper salts to form on the conductors.

The perfect varnish will keep its insulating qualities permanently, will not become brittle or crack through the effects of heat, age, vibration, etc., will not soften at a temperature below 200 deg. C., will not corrode copper, and will at all times remain oilproof and waterproof. It is evident, if there is such a varnish or combination of varnishes, that it is not in common use, or we would not worry so much over the effects of moisture, etc., on the windings.

Of the numerous gums used in the manufacture of insulating varnish, the principal ones are shellac, resin, asphaltum, pitch, tar, kauri, manilla and copal. Solvents in use are turpentine, benzine, benzol, acetone, alcohol, bisulphide of carbon, linseed oil, china wood oil, etc. It is well known that these oils and gums contain vegetable acids which, under certain conditions, are free to attack the copper, and it is of great importance, when selecting an insulating varnish, to make sure that it is compounded in such a way that this effect will not occur.

Some years ago I had occasion to rewind the armature of a 10-hp. direct-current motor made by a prominent manufacturing firm. This machine operated under severe conditions, was often wet by water dripping from pipes above it, and the windings were soaked with lubricating oil. After six months' service several coils were burned out, and on stripping the winding and removing the tape from some of the unburned coils, the cotton covering on the wires was found to have the characteristic green discoloration due to the action of acid on copper. I had often observed this before, but never had seen it so bad as it was in this case. The coils had been impregnated with a linseed-oil varnish.

More recently, I observed a similar effect on a 50-hp. 550-volt alternating-current motor stator. The lower half had to be rewound. Only a few of the coils were burned out, but an examination of the insulation showed the presence of copper salts, and apparently, only where the coils had been soaked with lubricating oil. In this case I do not think the coils had been dipped in a linseed-oil varnish, but next to the conductors was a layer of varnished cambric which may have been the seat of the trouble. I believe it is bad practice to put oiled linen or varnished cambric next to the cotton covering of wires when there is a possibility of oil penetrating into it. In several cases where the field coils of motors had been insulated with it, I have noticed the green spots on the lower part of the bottom coils, where they came in contact with oil lying in the bottom of the motor frame. The acid had eaten through the small wires and caused open circuits. Those coils had not been impregnated with any varnish, but had merely been painted over with a black compound, probably made from an asphalt base, which gradually hardened and cracked, allowing the lubricating oil to come in contact with the varnished cloth next to the wires.

I have no intention of condemning linseed-oil varnishes, as I believe they can be made to fulfill the purpose of a good insulating medium, but I would suggest that a thoroughly oilproof finishing varnish be used over it. This will keep out lubricating oil and will help to prevent the rapid oxidation of linseed oil which tends to make the varnish brittle and porous.

I know of a 300-hp. direct-current motor that ran for five years under conditions that would try out any insulating compound. The speed was 1,400 r.p.m., the temperature of the machine when running was so high at times that the soldering at the commutator leads melted, and it was a common thing to see the machine, when idle, soaking wet with the condensation from the atmosphere. Yet, when I had occasion to repair some coils on it, which had been damaged through the breaking of the end retaining band of the armature, I found them easy to lift out, the varnish flexible and apparently in perfect condition and no signs of copper salts on the conductors. During the time previous to the accident the armature had not been removed, baked or dipped, and there was always more or less oil from the bearings on the back of the windings. This machine was made in England, and the firm's representative said it had been treated with a compound made from a paraffin base, which had no affinity for oil, yet has all the qualities of a good insulating varnish. It looked good to me, and I used a considerable quantity of it afterward with good results. I should like to have some of the better-informed readers of *Power* discuss this very important question of insulating varnishes. H. WILSON.

Toronto, Ont., Canada.

## Our Mistake

In *Power* of Dec. 14, 1920, page 949, you make a statement that, "hydrogen cannot be disengaged from water or steam at ordinary furnace temperatures." This statement is in error. I have made thousands of cubic feet of hydrogen, 99.7 per cent pure over iron with steam, at a furnace temperature of 1,000 deg. F. and millions of cubic feet at a furnace temperature of 1,400 deg., 99.9 per cent pure. R. E. MILLAR.

Colwyn, Pa.

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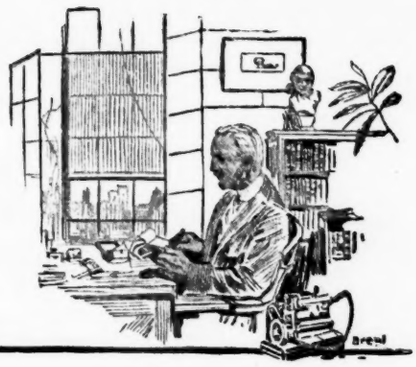
Your editorial comment interests me because we manufacture water gas by passing steam through hot coal or coke.

"Kent," Eighth Edition, page 829, states as follows: "Water Gas—Water gas is obtained by passing steam through a bed of coal, coke or charcoal heated to redness or beyond. The steam is decomposed, its hydrogen being liberated," etc. W. M. BOOTH.

Syracuse, N. Y.

# INQUIRIES OF GENERAL INTEREST



**Lame Running and Jumping of Pump**—What would cause a feed pump to run lame on the instroke and start with a jump on the outstroke? P. J.

The trouble may be caused by a defective suction valve that fails to open fully during the instroke and is not tightly closed during the outstroke.

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**Type of Condenser for Refrigeration Plant**—What type of atmospheric condenser requires the least water per ton of refrigeration? G. M.

Theoretically, all types should condense the same amount of gas with equal amounts of water. The difference between several types is solely in the variation in head pressure. The counter-current bleeder condenser still maintains its lead and is manufactured by all refrigeration-machine builders.

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**Beveled Hub of Cylinder Head**—Why is the portion of the cylinder head of our engine that projects into the cylinder cut off with a bevel on one side? A. E.

The shoulder of the hub for centering the cylinder head is cut away so it will not obstruct connection of the steam passages with the interior of the cylinder. If the cylinder were made long enough to require no such removal of material from the hub, there would be a higher percentage of cylinder clearance volume, thereby resulting in less economical use of steam by the engine.

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**Stopping Leaks at Mud Rings of Old Boilers**—We have three locomotive-type boilers that leak badly at the mud rings of the water legs. The boilers are badly needed until we have completed the installation of water-tube boilers. I have tried to stop the leaks by calking, but it does not hold. Can you suggest an inexpensive method of temporarily stopping the leaks in the old boilers? H. B. B.

If the openings are small and the water legs of the boilers are washed clean, the leaks probably could be temporarily stopped by spreading bran or cornstarch in the bottom of the water legs to a depth of about one-half inch, the remedy depending on the material becoming deposited in the leaky openings when carried to them by an outflow of water.

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**Power Developed in Operation of Pump**—What number of horsepower is developed in the operation of a single, double-acting steam pump having a water cylinder 14 in. bore and 18-in. stroke of piston, making 24 r.p.m., pumping against 85 lb. pressure? J. J. C.

Neglecting the reduction of piston displacement due to the presence of the piston rod, the water horsepower, or useful work developed would be

$$85 \times \tfrac{18}{12} (14 \times 14 \times 0.7854) \times 24 \times 2 \div 33{,}000 = 28.53 \text{ hp}$$

The power developed by the steam end would depend on the mechanical efficiency of the pump. A mechanical efficiency of 75 per cent would require development of 28.53 ÷ 0.75 = 38.04 indicated horsepower in the steam cylinder of the pump.

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**Relative Value of Coal Deprived of Volatiles**—Having coal containing 12,000 B.t.u. per lb. and 30 per cent volatile, what would be the loss if burned to a point where the volatile is consumed and then extinguished for use as fuel elsewhere; and what would the remaining coke be worth per ton if the original coal was worth $6 per ton? H. G. E.

Coking of bituminous coal in modern beehive ovens yields about 60 per cent of the original weight as marketable coke with expulsion of about 30 per cent of the volatile matter from the coal. All the volatile could not be driven off without the loss of such a high percentage of total combustibles as to render the coking process very extravagant. The percentage of weight retained would depend on the coking process employed, and the value of the residue for fuel would depend on its analysis.

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**Measuring Vacuum Without Steam and Vacuum Gage**—How can inches of vacuum be measured without the use of a vacuum gage or a mercury column? J. K.

A steam-engine indicator connected to an engine cylinder or condenser will give the number of pounds pressure per square inch below the pressure of the atmosphere, and that number of pounds of pressure, divided by 0.491 will give the number of inches of vacuum shown by the indicator; or for practical purposes multiply the number of pounds pressure per square inch below atmosphere by 2.

Or hermetically connect the supposed vacuum or partial level, multiply the number of pounds pressure per square inch below atmosphere by 2 and subtract the product from 30. Or hermetically connect the supposed vacuum or partial vacuum with the upper end of a vertical glass tube whose lower end is submerged below the surface of water that is exposed to the pressure of the atmosphere. Then as mercury is about 13.58 times the weight of water, the number of inches of water forced up in the tube above the water surface exposed to atmospheric pressure, divided by 13.58 will be the approximate number of "inches of vacuum" in the condenser or other vessel that is connected with the upper end of the glass tube.

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**Circulating Exhaust Steam in Vertical Loop Radiators**—For drying grain we have four vertical-pipe radiators supplied with exhaust steam, from which we do not obtain sufficient heat for our purposes. Each radiator contains 800 ft. of 1-in. pipe screwed into a cast-iron base. The pipes are in pairs having their upper ends connected with return-bend fittings. Could we not get better results if we connected each radiator drain with an open-air vent pipe? C. B.

On account of the difficulty of removing air from the loops, good circulation of exhaust steam is not readily obtained in this type of radiator, especially if the pressure of the steam as supplied to the radiator is only a pound or two above the pressure of the atmosphere and the returns are discharged direct to the atmosphere. Hence, operation of the radiators would be improved but little if at all by independent vents to the atmosphere, and there would be much waste of steam by short-circuit through the bases of the radiators. Better results would be obtained by connecting the returns to a vacuum system capable of maintaining at least 10 in. vacuum, for promptness in removing the air when starting up the system, after which the vacuum could be reduced to the requirement for maintaining satisfactory circulation.

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[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# The Bituminous Coal Situation

## The Nature of Coal Prices—Genesis of the Coal Strike—Inherited Deficit of 1920—Transportation the Leading Factor

THERE are two facts of fundamental importance which must be kept in mind in studying bituminous-coal prices. The first is that coal is a necessity of life and that the demand for it is highly inelastic. Not only is coal a necessity, but it is one for which substitution on a large scale is impossible. The second point is that this rigid and unyielding demand is in times of shortage concentrated upon a limited part of the total output; namely, that portion available for spot delivery known as "free coal." The bulk of the coal shipped is under contract, and probably not over one-fourth of it is available to meet the spot demand. In times of shortage this margin is greatly restricted, while the number of purchasers for spot coal increases, since the shortage usually means curtailment of production and the operators are, therefore, unable to meet the quotas called for by their contracts. When that happens, the price is likely to rise in spectacular fashion. The effect of these two fundamental principles—the inelasticity of the demand for coal and the contraction of spot tonnage in times of shortage—is that a slight maladjustment between supply and requirements may cause a great increase in spot price, and this is about what happened in 1920. On the day of the Armistice coal in storage was about 63,000,000 tons, the greatest amount in the history of the country. In building up so large a reserve, the Fuel Administration wanted to prevent a recurrence of the suffering of the preceding winter and foresaw a progressive diminution in the rate of production as the selective draft made further inroads on the working force at the mines. Under the conditions that prevailed after the Armistice, this reserve was greatly in excess of that actually needed.

*Through the courtesy of Senator Walter E. Edge, "Power" is privileged to present the outline of a letter written him by George Otis Smith, Director of the United States Geological Survey, in answer to a request for his views on the present coal situation and the reasons, if any, for the prevailing shortage and high prices. Mr. Smith draws a sharp distinction between the anthracite and the bituminous industry. Although both kinds of coal are used for domestic purposes (in 1917 about 53,000,000 net tons and 57,000,000 net tons respectively) the industries producing them differ radically in organization, demanding separate consideration. The letter deals with bituminous coal.*

The winter of 1918-19 proved exceptionally mild. There was a business reaction. The demand for export had not yet set in and because of all these things the market for coal fell off. When the Fuel Administration withdrew its maximum prices on Feb. 1, 1919, consumers waited to see which way the market would go. In some districts the price rose; in others, notably the Middle West, the price declined materially. The consumers, however, were not satisfied with the prices offered even though they were trending downward. They remembered the days of cheap coal before the war and recalled that as late as 1915 the average mine realization on all bituminous coal was only $1.13. Had the cost figures been available as they were during the war period, the buying public would have known that the prices then charged, in the Middle West particularly, were down to a minimum and likely to increase with the return of cold weather. Instead of taking advantage of the low prices to maintain unimpaired their reserves against the following winter, consumers held off and waited for the price to drop. The result was that during the second quarter of 1919 the mines of the country worked about 26 hours of the 48 in the week. In some districts the effect of no market was much greater, as in the State of Illinois, where during April, May and June, 1919, the average work offered to the miners was 19 hours out of the week, or less than 2½ days. The condition of discontent produced by the depression of the industry at this time was the underlying cause of the great strike of 1919. Men who, during the war, had grown accustomed to fairly steady work at the existing wage scale, found that scale inadequate when they could get work at best for only three days a week and sometimes not at all. In Southern Illinois, where the depression was severest, the strike was born, and it grew directly out of the "buyers' strike," as someone had aptly termed the reluctance of the purchasers to take their coal in customary amounts.

Not until August, 1919, did the consumer awake to his interest. The market began to improve and coal to move. After the United Mine Workers announced their demand for a thirty-four hour week and an increase of 60 per cent in wages, it quickened again and the recovery changed into a mad scramble as it became evident that the efforts to peaceably adjudicate the controversy between operators and men were unavailing. With preferential car supply furnished by the Railroad Administration, production during the last month before the strike broke was the largest in any October on record. These last-minute preparations on the part of consumers had increased materially the reserves on hand at destinations, but the stock was still short of that necessary to carry the country through a protracted industrial struggle. For a period of from one to six weeks production ceased in fields representing about two-thirds of the capacity of the country, the loss approximating 26,000,000 tons. To meet the emergency, the maximum prices of the war period were restored under the Lever Act and the Fuel Administrator delegated to the Director General of Railroads the power to receive and distribute for emergency use the coal loaded at mines that continued to work.

Had the loss of tonnage been generally distributed over the country, it would have been serious enough, but as a matter of fact some districts were much harder hit than others. Increased production in the non-union fields of the Middle and Southern Appalachian and the states of the far Southwest could not make up for the shortage in the Middle West and Northeast. As the strike progressed, the reserves in the latter areas were eaten down to the bone, and during the last days before the settlement that sent the men back to work, reports of physical suffering and actual closing down of plants for lack of fuel were received. The year 1920 opened with production at a rate sufficient to meet current requirements in view of the limitations on export and to permit a slow accumulation of consumers' stock. To those who, looking forward, attempted to foresee developments of 1920, it was clear that the coal industry had before it a considerable task. Business was active, the foreign demand feverish, and the requirements for week-to-week consumption, therefore, large. In addition 1920

would have to produce enough coal to build up the depleted reserve, in some regions well-nigh exhausted by the strike. This double duty of providing for current consumption and reaccumulating the necessary reserve, made it apparent that the 1920 requirements would be large. There was no reason to expect that they would equal those of 1918 when, in addition to meeting the wartime consumption, some 30,000,000 tons were put in storage. But it was very clear that they would exceed the production in 1919 when, first because of the buyers' strike and later because of the miners' strike, the output fell far short of consumption. It seemed more reasonable to expect that the requirements for 1920 would be in the neighborhood of the 550,000,000 tons produced in 1917.

### Decision of the Bituminous Coal Commission

In the meantime the controversy between miners and operators was before the Bituminous Coal Commission, which in March announced its decision, awarding a wage increase of approximately 27 per cent, which included the 14 per cent previously granted by the Fuel Administrator. The operators, who had undertaken to absorb the 14 per cent advance without an increase in maximum prices, declared themselves unable to absorb the advance of 27 per cent and in order to make possible the necessary readjustment of prices the Government maxima were withdrawn, effective March 31. At the time this decision was announced, the prospects for steady and large production appeared bright, and in the last week of March, just before the prices were lifted, a production of 11,000,000 tons was attained, a fair performance for that season of the year.

The order lifting the prices had been issued March 19 to take effect at midnight March 31. On April 1 occurred an unexpected event which was to affect profoundly the coal market. The miners' strike had been an internal quarrel within the industry. The outlaw switchmen's strike of April 1 was entirely beyond the control of the coal industry and resembled guerilla warfare more than an organized strike. The effect on the production and distribution of coal was immediate and far-reaching. No sooner were the rail gateways clogged with freight than delays in the placing of empty cars at the mines brought about the most acute car shortage in history. During the week of April 17 the working time at the mines averaged only 43 per cent of full time. Production fell to eight or nine million tons per week, and throughout the month of April and most of May the weekly rate of production was less than the current consumption plus the exports, so that on June 1 commercial consumers had on hand only 20,000,000 tons, the lowest figure on record.

### Interstate Commerce Commission Issues Service Order No. 1

As a result many consumers were actually short of coal and many others, particularly the public utilities, hard hit. The Interstate Commerce Commission finally declared that a condition of emergency existed and on May 20 issued its Service Order No. 1, designed to overcome the congestion and expedite traffic. In my opinion that declaration of an emergency was justified by the facts. The Geological Survey scrupulously refrained from the use of the words "shortage of coal," trusting that the facts concerning production and supplies would speak for themselves.

There were not lacking at that time those who denied the existence of a shortage and predicted that the output during the remainder of the year would make good the deficiency. The fact that the deficiency has since been largely made up does not alter the reality of the shortage that existed in the spring and summer. It was not, indeed, as acute as the shortage of the winter of 1917-18; there were relatively few plants actually shut down for the lack of coal, but stocks were low and the consumers knew it. Deliveries on contracts were inadequate to meet the current requirements of many plants, which were, therefore, forced to enter the spot market. To make matters worse, an export demand of unheard-of intensity suddenly developed, and the resulting situation may be likened to what happens after a great disaster resulting from an act of God. After a San Francisco earthquake the customary restraints of organized society break down; the lawless element is unchained; a condition of near-riot results, and to restore order the application of martial law is necessary. Consumers unable to obtain the coal they needed and uncertain when the congestion of transportation caused by the switchmen's strike would end and permit the resumption of normal coal shipments, bid against one another and sometimes against themselves. Prices rose 100, 200, 300, 400, or even 500 per cent, bearing, in many instances, no relation whatever to the cost of production. The question as to whether or not the men in the coal trade who accepted these large prices are culpable stands on the public's conception of the coal business. Were the production and distribution of coal regarded as a public utility, like the railroads, it would be within the accepted power of the public to control prices, but so long as we recognize the mining and distribution of coal as a private business, such regulation is neither possible under existing law, nor sanctioned by prevailing conceptions of the Government's relation to business.

Throughout the period of high prices from April to November, the predominant cause limiting output has been transportation. Expressed in terms of the full time of mines representing more than half the tonnage in the country the loss of working time attributed to transportation service ranges from 50 to 20 per cent.

Thanks in part to the service orders issued by the Interstate Commerce Commission, in part to the joint efforts of the operators and the Committee of Railroad Executives, and very largely to the co-operation of labor, the production of coal has been steadily increased since the profound depression of last April and May. The month of October, 1919, will stand as one of the periods of heavy output of recent years. The total output since Jan. 1 now stands at 512,500,000 tons and suggests that by the close of the year production may reach 550,000,000 tons, the mark attained in 1917. That the deficit is being overcome is shown by the declining prices reported from practically all districts.

When bituminous prices will strike bottom depends, more than anything else, on the rate of output in the next few weeks, at the end of which we may expect a condition of relative oversupply of soft coal with many mines closed down through lack of orders.

*Boy*—Where has the ash bin?
*Man*—Over to see the coal chute.
*Boy*—That joke is like a firebox—grate.

# Boston Engineers Discuss Water Power

A JOINT meeting of the Boston Society of Civil Engineers, the Boston Section, American Society of Mechanical Engineers, and the Boston Section, American Institute of Electrical Engineers, was held in Tremont Temple, Boston, Friday evening, Dec. 17, 1920. Preceding the joint session there was a short business meeting of the Boston Society of Civil Engineers to consider the indorsement of a series of resolutions in relation to the efforts being made by the New England Conference for the protection of National Parks. These resolutions, preliminary action toward the indorsement of which was taken at the meeting, are as follows:

RESOLUTIONS CONCERNING A PROPOSED AMENDMENT OF THE FEDERAL WATER-POWER ACT, ETC.

Whereas, The Federal Water-Power Act passed by the 66th Congress authorized the Water-Power Commission to issue licenses for "constructing, operating and maintaining dams, water conduits, reservoirs, power houses, transmission lines or other project works" in the National Parks and Monuments on exactly the same basis as in the Natural Forests and other public lands; and

Whereas, Irrigation interests are seeking rights for storage reservoirs in the National Parks and are strongly urging the passage of the precedent making Falls River Basin Bill, otherwise known as the Smith Bill (H. R. 12,466), which has passed the Senate and is pending before the House of Representatives with a favorable report, and which grants easements for "irrigation plants, dams, reservoirs, canals, ditches, pipes and pipe lines" in Yellowstone National Park; now, therefore,

Be It Resolved, That the Boston Society of Civil Engineers indorses the attempt to secure an amendment of the act creating the Federal Power Commission which shall exempt the National Parks and Monuments from its provisions; and also

Be It Resolved, That the society specifically opposes the Falls River Basin Bill (H. R. 12,466), believing it to be establishing a dangerous precedent and doing irreparable injury to a large section of one of the most important of our National Parks; and furthermore

Be It Resolved, That the board of Government of the Society be authorized and directed to co-operate with other organizations working for the protection of the National Parks and Monuments.

Following this, at the joint session, Professor Harold K. Barrows, of the Massachusetts Institute of Technology, read a paper on "Water-Power Development in New England." Professor Barrows' paper, which was illustrated by lantern slides showing plots and tables, summarized the water-power data, both developed and possible, in the New England States, with some references to New York State. Variations in rainfall and in the water run-off in the various streams of importance were shown by curves and plots covering a number of years. Averages of these values from month to month during various years were discussed, together with the effect of storage in smoothing out the curves. The financial questions affecting the commercial success of a water-power development were outlined, the items involved being: The maximum power available; the percentage of the year a given amount of power is available; the cost of development, including dams, purchase of land that would be flooded, power plants and transmission lines; and market for power.

New England, according to the speaker, has about 2,000,000 water horsepower available, of which about one-half is developed. The majority of this, however, is in the northern states, while the demand for power is in the southern states of Massachusetts, Connecticut and Rhode Island. The development is complicated by various state laws, such as that of Maine, which forbid transmission of water power across the state line. The problem of development is further complicated by the legal rights of various property owners along the streams. Thus a development usually requires co-operative action or agreement among a large number of people who often have conflicting interests. Following Professor Barrows' paper Henry I. Harriman, president of the New England Power Co., spoke of the interests of New England in the plan to make the St. Lawrence River navigable from the Great Lakes to the ocean. This project, which is backed by the West to give an all water outlet to the high seas, has immense possibilities from the standpoint of power generation. The flow of the St. Lawrence is estimated at 241,000 cu.ft. per sec. with a maximum variation of 25 per cent. The proposed dam to raise the level of Lake Ontario by three feet, it is estimated, will reduce this variation to about 10 per cent. The fall from Lake Ontario to Montreal is 220 ft., of which 91 ft. is on the border, while the remainder is in Canada. Of the 24 billion killowatt-hours per year made available by the navigation dams, about half would probably come to the United States either by right or by purchase, and probably half of this, or 6 billion killowatt-hours, would be marketed in New England on account of its geographical location. It is estimated that this would supply all New England's power requirements, including about five-sixths of its railroad power requirements, and leave probably a half billion killowatt-hours per year available for expansion.

New England's railroads use 6 million tons of coal annually, and electrification of its heavy haulage lines would save five-sixths of this, with a money saving which Mr. Harriman estimates would pay for the electrification in two years.

On the other side of the question are the loss to Buffalo of the transfer of freight from the Lakes to rail at that city, the loss of traffic to the railroads and the Erie Canal and the loss of commerce passing through the ports of Boston and New York. Mr. Harriman pointed out, however, that only the heavier, low freight-rate commodities would be shipped by the new route, thus releasing much needed railroad equipment for hauling the more profitable freight. He also argued that the cheap power made available would more than make up for the loss in commerce, especially to New England.

As to the cost of the power he estimated that the cost for the dams necessary for navigation would be about one mill per killowatt-hour available. The whole cost of the project should allow the delivery of power for not over one cent per killowatt-hour.

## Cornell Man Wins A. S. M. E. Prize

Howard G. Allen, of Chicago, a graduate of Cornell, has won this year the student prize that is awarded annually by the American Society of Mechanical Engineers. The prize is given to that member of the student branch of the society who presents the best paper during the year, as judged for its practical or theoretical applicability, completeness, conciseness, originality of matter and value as a contribution to mechanical-engineering literature. The winning paper was entitled "Wire Stitching Through Paper."

This prize is made possible by a fund of $1,000, which was established through the generosity of a member of the A. S. M. E. as an incentiv to young engineers to undertake original work. A similar fund provides an award for the best paper submitted by a "junior" member. Student branches are maintained by the society in many universities and technical schools.

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Plans are being made in Australia for the building of an electric generating station at Morwell, eighty miles east of Melbourne. The site selected for the plant is close to a deposit of some 150,000,000 tons of brown coal, which is within an area of about one square mile. In addition there is estimated to be available in the neighborhood over 20,000,000,000 tons of lignite. The initial capacity of the plant is to be 50,000 kw., and it is estimated that the brown coal on hand here will run the power house at that output for 150 years. It will be possible to extend the plant when necessary to 100,000 kw. capacity.

## Engineering Council Holds Final Meeting

Engineering Council has passed out of existence with the year 1920; its place is taken by American Engineering Council, which is the executive, or governing, board of the Federated American Engineering Societies. It is not expected that this change will end or in any way interrupt the good work that Engineering Council has been doing; Council's functions are being smoothly transferred and taken over by its successor, and are to be managed in much the same way as before.

This fact was evident at the final meeting of Engineering Council, of which a brief report follows, and at the first meeting of American Engineering Council, reported in *Power* for Dec. 28, 1920. The meeting of Engineering Council was held in Washington on Nov. 16, just a day before American Engineering Council's first meeting at New York.

At this final meeting a number of committees made their reports, which were accepted and referred to American Engineering Council for continuation of the work.

The committee on Classification and Compensation of Engineers made a very careful report of its work. This committee was organized early in 1919 to work out a plan for the classification, promotion and compensation of engineers in governmental and railroad services. A suitable schedule was prepared some time ago and presented to a great number of engineering societies and prominent individuals, and a generally favorable response was received. The committee recommended in its report, which was adopted, that the appropriate Congressional committee be urged to increase the pay of Government engineering staffs and that its own work be carried on by American Engineering Council.

The final report of the License Committee was approved, and the committee was discharged with an appreciation of its work. This report consists of a suggested model law for the registration of architects, engineers and land surveyors.

A communication from the American Society of Civil Engineers was read in which that organization finally accepted the proposal for the dissolution of Council. There was, of course, no other course open, as the three other founder societies, having joined the Federation, are to withdraw their support from Council; so that the Civil Engineers, if they had persisted in their original request that Council continue its work, would have found themselves in the anomalous position of being the sole member of a co-operative organization.

A formal report to United Engineering Societies was approved, recommending the discontinuance of Engineering Council and the transfer of its work to American Engineering Council; United Engineering Societies has since adopted this report and has made the necessary changes in its by-laws.

Philip N. Moore, J. Parke Channing and the secretary were requested to prepare a final report, which would be also a history of the activities of Engineering Council from its beginning, including its unfinished business, to be submitted to United Engineering Societies for transmission to the member societies.

During the afternoon the representatives and guests visited the Government offices and had the pleasure of meeting the men who are at the head of the various engineering departments of the Government. The day was rounded out by a farewell dinner at the Washington Hotel.

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A Committee on Water Power and Conservation, headed by Dr. F. H. Newell, has been appointed by the Board of Directors of the American Association of Engineers. The other members of the committee are Edmund T. Perkins, president of the Edmund T. Perkins Engineering Co. of Chicago; Charles E. Waddell, consulting engineer, of Asheville, N. C.; L. F. Harza, hydro-electric engineer, of Chicago; H. A. Allen, consulting engineer, of Chicago; and J. B. Lippincott, of Los Angeles.

## Relation of Baumé Gravity to Volatility in Gasoline*

Until a few years ago gasolines were rated according to the Baumé gravity, those of high gravity being known as high-test gasolines and those of low gravity as low-test products. Even today a large amount of gasoline is marketed entirely on gravity tests. The average automobile owner is not familiar with any other test and for that reason will always select the gasoline showing the higher gravity regardless of the source of the product. The distillation test, which shows the volatility of gasoline, was rather difficult to establish in the oil industry and it has never been adopted by the average consumer, although in some states retail stations are compelled by law to show the distillation test of the products sold.

At one time when gasoline was obtained entirely by "straight-run" methods and from crudes that were not much different in chemical constituents, gravity measurements were a fairly reliable index of the quality of the gasoline, as they indicated the approximate volatility. The production of gasoline from heavy crudes, such as those of California, and finally the introduction of blends of refinery products with natural-gas gasoline proved definitely that, unless its source was known, the gravity test was not satisfactory as a means of judging the quality of a gasoline. It is possible to blend casinghead gasoline with kerosense and obtain a product having the same gravity as a high-test straight-run gasoline, although in volatility the products are entirely different.

That the use of gravity as means of indicating the quality of gasoline is responsbile for a number of misunderstandings is well illustrated by the various state specifications governing the quality of gasoline that can be marketed within the state. Several of the states have specifications based on gravity tests alone, and in a number of cases the gravity requirements are such that it is impossible for the refiners to meet the tests and at the same time maintain sufficient production to meet requirements. A number of the gravity requirements in state specifications are based on tests of products from Pennsylvania crude, although, as shown in a later connection, products of equal volatility but derived from different crudes may differ as much as 10 deg. in Baumé gravity. Gravities of samples collected in 1919 varied from 30.6 to 74.3 deg. Baumé (0.872 to 0.682 sp.gr.) which, if rated according to gravity alone, would indicate that the heavier products belonged to the fuel-oil class. The fuels of low gravity, however, consist largely of benzol and other coal-tar products that are as volatile as gasoline.

In order to show definitely the relation between gravity and volatility of gasolines derived from different crudes, samples were selected representing products made by refineries that obtained crude from adjacent producing fields and do not blend casinghead with their product. Three samples representing gasoline from California, Oklahoma and Pennsylvania crude having practically the same distillation range had Baumé gravities of 50 deg., 53.7 deg. and 60.2 deg. respectively, a difference between gasolines from California and Oklahoma crudes of 3.7 deg. Bé. and between Oklahoma and Pennsylvania crudes of 6.5 deg. Bé. and between California and Pennsylvania crudes of 10.2 deg. Bé. Another series of three samples showed differences of 2.2 deg. Bé. between California and Oklahoma products, 5.6 deg. Bé. between Oklahoma and Pennsylvania and 7.8 deg. Bé. between California and Pennsylvania. This would indicate that, in general, a Pennsylvania gasoline having a certain volatility is 2 to 4 deg. Bé. higher in gravity than one of equal volatility from Oklahoma crude and is 8 to 10 deg. Bé. higher than one from California crude.

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In an article entitled "Canada's Use of White Coal," which appeared recently in *Power*, there was a table which showed the total horsepower developed in various districts of Canada. It is interesting to note that in one of these districts the total horsepower shown amounted to six. One is inclined to wonder how many central-station plants combined to produce this amount of power.

*Extracted from Bulletin No. 191, Bureau of Mines.

## Poisonous Gases From Carbon-Tetrachloride Fire Extinguishers*

As a result of the death of two men in the Navy Department from breathing fumes from carbon tetrachloride used on a fire and the overcoming of an employee of the Bureau of Mines while fighting a fire with carbon-tetrachloride liquid, an investigation of the decomposition products of carbon-tetrachloride fire extinguishers was made. Experiments were conducted by two methods. The first consisted in applying the liquids to actual fires and to hot metal in a closed room of 1,000-ft. capacity, where the gaseous products, mixed with the air, could be retained and analyzed. The second method was to pass the vapors in air through heated tubes of iron or quartz, where humidity of the air and the temperature could be controlled.

These poisonous gases were found in the air of the gas chamber: Phosgene, which is intensely poisonous, was formed in toxic quantities; chlorine, which is also poisonous, was formed in smaller amounts; hydrogen chloride, which is irritating and also poisonous, was formed, and there was considerable vapor of carbon tetrachloride, which is a dangerous anesthetic.

One-half the carbon-tetrachloride liquid was decomposed to poisonous gases in some of the tube experiments.

As a result of the experiments it is recommended that carbon-tetrachloride fire extinguishers be not used on fires in closely confined space where conditions are such that the user cannot escape without breathing the fumes. The army type of gas mask offers good protection from the fumes.

It is not the intention of this paper to discourage the use of carbon-tetrachloride extinguishers, which are excellent for stopping incipient fires, but rather to point out the danger which can occur with their application.

The average user of a carbon-tetrachloride extinguisher does not know that the decomposition products are poisonous until it is too late. It would, therefore, seem that manufacturers of such apparatus should put a plainly lettered caution plate on each extinguisher, stating that the fumes from using the extinguisher must not be inhaled, as they are poisonous.

## Test on a Solid-Injection Oil Engine

A Ruston & Hornsby solid-injection oil engine was tested by Captain R. Sankey. His report, which appeared in *Engineering*, is as follows:

Object of Test—The object of the test was to ascertain the oil consumption per brake horsepower at various loads.

Type of Engine—The engine tested was of the horizontal type, having two side-by-side cylinders, firing alternately, and cranks at 0 deg. The flywheel was on one side of the engine, and the load was applied by a Heenan & Froude brake bolted to the flywheel boss. The particulars of the engine are: Cylinder diameter, 18¾ in.; stroke, 30 in.; revolutions per minute, 175; rated brake horsepower, 260. This type of engine works on a four-stroke cycle. During the out stroke, following the exhaust of the products of combustion, pure air is drawn in and then compressed to about 450 lb. per sq.in. during the following in stroke. The compression temperature is amply sufficient to ignite the oil, which is forced into the cylinder at about the turn of the stroke by an oil pump, giving an adequate pressure to atomize the oil. Owing to the high compression temperature, preheating of a hot bulb is unnecessary, and the engine can start from cold. The combustion is therefore partly at constant volume and partly at constant pressure, which is thermodynamically somewhat more efficient than combustion at constant pressure.

Method of Testing and Apparatus Used—The method of testing was that in current use at your works, and all measurements were taken by your staff under my supervision. As already stated, the load was applied by means of a Heenan & Froude hydraulic brake. The weights used with this brake were compared with standard weights and found to be accurate. The oil consumption of each cylinder was measured separately by arranging so that the oil surface in the supply tank broke away from the needle point at the moment of starting the test for each load, and similarly at the moment of completing each half-hour's run, and then obtaining the weight of oil thus required by the difference in weight between the full and partly emptied can used for pouring the oil into the tank. The weights used for weighing the oil were checked against standard weights and were found to be correct and well within the limits of the errors of the test. The balance used turned with ⅛ oz.

CONSUMPTION PER B.HP.-HR. AT VARIOUS LOADS

Lower calorific value of oil = 18,050 B.t.u. per lb.

| Proportion of Full Load | Average R.p.m. | Average B.hp. | Oil Consumption, Lb. of Oil per B.hp.-hr. |
|---|---|---|---|
| Overload | 174.1 | 261.1 | 0.403 |
| Full load | 175.57 | 235.9 | 0.401 |
| Three-quarter load | 177.15 | 178.25 | 0.401 |
| Half load | 179.33 | 119.93 | 0.405 |
| Quarter load | 181.1 | 60.4 | 0.508 |

The speed was obtained by readings of a revolution counter taken every quarter of an hour. Indicator diagrams were taken simultaneously from each cylinder every quarter of an hour. Three samples of oil were taken, one from each of the barrels used, and the calorific value was subsequently determined. The calorific value of all three samples was the same; namely, 19,260 B.t.u. per pound higher calorific value. The lower calorific value, which is the value to take in accordance with the rules of the Institution of Civil Engineers, works out to 18,051 B.t.u., assuming 13.9 per cent of hydrogen.

Log of Tests—The engine was started at 8 o'clock, and ran at about half load until 9:10 o'clock, when full load was applied. The full-load test began at 9:20 o'clock and continued for three hours. The load was then quickly lessened to three-quarter load, which was maintained for one hour, after which the load was reduced in succession to half load and quarter load, each for one hour, after which the engine was run with no load for a quarter of an hour, then an overload approximately of 10 per cent was applied for half an hour. Lastly, the quarter-load test was repeated for an hour, and the trial ended at 6 p.m.

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Experimental work on determining the compression and hardness values of white-metal bearing alloys at temperatures up to 100 deg. C. has been completed by the Bureau of Standards. A paper has been prepared, entitled "Some Properties of White Metal Bearing Alloys at Elevated Temperatures," a summary of which is as follows: An apparatus is described for determining the yield point and ultimate strength of white-metal bearing alloys at temperatures up to 100 deg. C. A new design of heating apparatus is described for determining the Brinell hardness of such metals in the range of temperature indicated. The results of compression tests and Brinell hardness tests at temperatures up to 100 deg. C. are given for five typical white-metal bearing alloys, including three tin-base alloys, one lead-base alloy and one intermediate alloy. These tests showed that the tin-base alloys maintain their properties better at elevated temperatures than those containing lead. Results of tests are given which indicate that up to 3 per cent the lead in a high-grade babbitt does not affect the yield point or ultimate strength at 25 deg. C. or 75 deg. C. Tests are described which show that the yield point of tin-base alloy is not affected by heating for six weeks at about 100 deg. C., but that the yield point is lowered in the lead-base alloy by heating for only two weeks at this temperature.

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The City of Winnipeg, Canada, is securing good results from its civic-owned hydro-electric plant, which is valued at $7,557,492. Electric power for lighting is furnished at $0.035 per kw.-hr., and for manufacturing as low as $0.005.

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Over half the coal that entered Switzerland in the first half of 1920 came from the United States.

*By A. C. Fieldner, S. H. Katz, S. P. Kinney and E. S. Longfellow, Research Laboratory, Pittsburgh Experiment Station, Bureau of Mines, in N. E. L. A. *Bulletin*, December, 1920.

## New Publications

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT. Published annually by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Cloth; 6 x 9 in.; 1,000 pages. Price, $4; free to A. S. M. E. members.

The condensed catalog section consists of about 750 pages, in which generally one or two pages are devoted to a description of the product of each of the 572 firms represented. This section takes in: Power-plant equipment; testing, measuring and recording apparatus; power-transmission machinery; conveying, hoisting and transporting machinery; metals, alloys and other materials; metal-working machinery, machine tools and accessories; compressors, blowers, pumps, hydraulic machinery, industrial machinery, steel-plate work. The remaining pages include a classified mechanical equipment directory and a directory of consulting engineers. It is a high-grade, well-gotten-up book.

THE FIREMAN'S HANDBOOK AND GUIDE TO FUEL ECONOMY. By Charles F. Wade Longmans, Green & Co., Fourth Ave. and Thirtieth St., New York City. Stiff paper cover; 4¾ x 7 in.; 84 pages; illustrated. Price, $1 net.

As the title indicates, this little volume is published for the benefit of firemen and is written in as simple language as is possible, the aim being to point out the correct way to fire and otherwise handle boilers and furnaces, with a lucid exposition of the reason why. After treating the subjects of coal, heat in coal, steam, heat of steam, efficiency, etc., the reader is told what happens when coal is burned, what gases are formed in burning the fuel, and then the book goes on, to treat very briefly, of boilers, mechanical stokers and superheaters. Other subjects taken up are gas-fired boilers, boiler feed and water softening. A chapter on drains and traps is followed by one on boiler fittings, or mountings, the two concluding chapters dealing with boilers and boiler efficiency. The volume contains considerable information for the man not versed in boiler-room operation.

## Obituary

**Charles Bavier**, chief engineer of the Metropolitan Life Insurance Building for over 20 years, died recently at the age of seventy at Mt. McGregor Sanitarium. He was a Mason and a member of the American Society of Mechanical Engineers, of the American Society of Heating and Ventilating Engineers and of the Phœnix Association of the N. A. S. E. Mr. Bavier was a widower and is survived by two daughters and a son.

## Personals

**G. A. Schneider**, mechanical engineer with the Standard Steel Car Co., has returned from France and is now in Chicago.

**Ethan Viall**, editor-in-chief of the *American Machinist* and for ten years a member of the staff, has resigned to become a member of the firm of T. W. Minton & Co., Barbourville, Ky., the largest producer of hickory dimension stock in the United States.

**Herbert R. Connor** has discontinued his services with the Phillips Rice Milling Company and M. Phillips & Co., of San Francisco, as chief engineer and has opened an office in San Francisco as consulting mechanical engineer.

**G. C. Van Den Boom** has been appointed Western manager of compressor and engine sales of the Chicago Pneumatic Tool Company, with headquarters at Chicago.

**A. L. Vining**, formerly master mechanic for the Bayless Manufacturing Co., Austen, Pa., recently became master mechanic and chief engineer with the Union Wax and Parchment Paper Co., Hamburg, N. J.

**J. F. Carman** has resigned as chief engineer for Abraham & Straus, Brooklyn, to accept the position made vacant by the death of Charles Bavier, chief engineer of the Metropolitan Life Insurance Building in New York City.

## Society Affairs

**The National Board of Boiler and Pressure Vessel Inspectors** will hold its first annual meeting at the Statler Hotel, Detroit, Mich., Feb. 2, 3 and 4. Details of the program will be furnished later.

**Cleveland Section**, Association of Iron and Steel Electrical Engineers, will hear an address on Jan. 10 on "Proper Selection of Carbon Brushes," by L. A. Heath, of the Morganite Brush Co.

**Toledo Section, A. S. M. E.**, will meet at the Toledo Commerce Club on Jan. 11. Dr. Quillan, of Toledo University, will speak on "The Need of Business Training in Engineering."

**Columbus Section, A. S. M. E.**, will meet on Jan. 14 at the Engineers' Club, Southern Hotel. "The Story of Petroleum," a motion picture from the Bureau of Mines, will be presented.

**Hartford Branch, A. S. M. E.**, will meet at the City Club on Jan. 10. C. L. Lesher, the editor of *Coal Age*, will speak on "The Responsibility of the Coal Consumer."

**The Society of Automotive Engineers** will hold its winter meeting at the Engineering Societies Building, New York City, Jan. 11-13. There will be a number of sessions devoted to consideration of various automotive problems, among them a Fuel Session, which will last throughout Thursday, the 13th. Social events will include "The Carnival" on Wednesday evening and the annual dinner at 7 o'clock at the Hotel Astor.

## Trade Catalogs

**The Brown Portable Conveying Machine Co.**, Chicago, is distributing a well-illustrated, 48-page, 8½ x 11-in. catalog of portable and sectional elevating, conveying, loading and unloading machinery for the rapid handling of all kinds of materials. This company is now offering, for direct subscription, a combination of preferred and common stock in order to secure a small increase in capital.

## COAL PRICES

Current mine quotations, with interesting comparisons, are given in the following tabulation:

| | Nov. 1919* | Aug. 1920 | 5 Dec. 1920 | 16 Dec. 1920 | 30 Dec. 1920 |
|---|---|---|---|---|---|
| Pittsburgh steam | $2.30 | $10.00 | $3.25 | $2.75 | |
| Pittsburgh screened gas | 2.30 | 12.00 | 3.75 | 3.25 | |
| Hocking | 2.50 | 9.00 | 3.00 | 2.50 | |
| Franklin, Ill. | 2.35 | 6.50 | 3.40 | 3.40 | |
| Indiana 4th vein | 2.35 | 7.50 | 3.25 | 3.25 | |
| Eastern Ohio, No. 8 | 2.35 | 10.50 | 3.40 | 3.00 | |
| Fairmont | 2.50 | 13.50 | 3.00 | 2.75 | |
| Kanawha | 2.60 | 14.00 | 3.50 | 3.00 | |
| S. E. Kentucky | 3.00 | 10.50 | 4.00 | 3.40 | |
| Western Kentucky | 2.35 | 5.25 | 3.75 | 2.75 | |
| Clearfield | 2.95 | 12.00 | 3.75 | 3.75 | |
| Cambria and Somerset | 2.95 | 13.50 | 4.75 | 4.65 | |
| New River | 2.70 | 14.00 | 5.00 | 4.75 | |
| Pocahontas | 2.35 | | | | |

* Government prices.

## New Construction

### PROPOSED WORK

**Me., Bar Harbor**—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., received bids for an electrical distribution system, at the radio station at Otter Cliffs, here; from E. S. Downs Co., 9 Campbell St., Newark, N. J., $18,951; G. E. Eng. Co., 22 Laight St., New York City, $20,813; J. R. Proctor Co., 74 Cortlandt St., New York City, $21,620.

**Mass., Boston**—The city is having plans prepared for a municipal building at Shawmut Ave. and Brookline St. About $300,000. J. A. Schweinfurth, 53 State St., Archt.

**Mass., Lynn**—The Bd. Educ. plans to build 3 schools: junior high, to cost $400,000; elementary, $50,000 and primary, $50,000. Architect not selected.

**Mass., Plymouth**—The Town Memorial Com. plans to build a 2 story, 127 x 250 ft. memorial hall including a steam heating system on Court St. About $250,000. Little & Russell, 45 Bromfield St., Boston, Archts.

**R. I., Woonsocket**—The Lafayette Worsted Co. Hamlet St., is receiving bids for a 4 story, 138 x 246 ft. factory including a steam heating system. About $350,000. W. F. Fontaine, Federal Bldg., Archt.

**N. J., Avon**—The city plans to build a pumping station. About $60,000. J. Thomson, Comnr.

**N. J., Kearney (Arlington P. O.)**—The Bd. Educ. is having sketches prepared for a high school on Devon St. About $600,000. Guilbert & Betelle, 2 Lombardi St., Newark, Archts.

**Pa., Byberry**—The Bureau of Hospitals, 34th and Pine Sts., will soon award the contract for additions to hospital buildings, including steam heating systems. About $75,000. J. P. B. Sinkler, 825 City Hall, Phila., Archt.

**Md., Annapolis**—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will receive bids until Jan. 12 for boiler plant equipment and piping. Noted Oct. 5.

**Md., Baltimore**—The General Chemical Co., Munsey Bldg., will soon award contract for a 50 x 59 ft. power house at Race and Winder Sts. J. G. White Corp., 43 Exchange Place, New York City, Archt.

**D. C., Washington**—The United States Engineers' Office, 305 Southern Bldg., rejected all bids for furnishing centrifugal pump, etc., for filtration plant.

**Va., Richmond**—The Crystal Ice Co., 525 Brooke Ave., is receiving bids for remodeling large building, to be used in connection with ice plant. About $50,000. R. H. Greene and W. P. Thurston, Merchants' Natl. Bank Bldg., Archts.

**N. C., Raleigh**—The Carolina Power & Light Co. plans additions to its plant connected with the operation of the street railway. About $51,600.

**Ga., Camp Benning**—The Philipsburgh Constr. Co., co A. O. Suetendael, 15 North Bway., Yonkers, N. Y., are low bidders on cold storage plant here, and are receiving sub-bids on 25-ton ice making and 10-ton refrigerating machinery, cork insulation, electrical work, etc. About $50,000.

**Ga., La Grange**—C. R. Callaway, Pres. of a committee of business men, will soon award the contract for a 6 story hotel. A steam heating system will be installed in same. About $350,000.

**Fla., St. Petersburg**—The William-Beers Ice Co. plans to build a 35-ton, electrically-operated ice manufacturing plant. About $100,000. H. Williams, Pres. H. Beers, Engr.

**Tenn., Gallatin**—The City Council of Gallatin is negotiating with the Union Traction Co. of Nashville for supplying power here. Plans include an 18-mile transmission line and a substation at some point between the two cities.

**O., Akron**—The Bd. Educ. plans to build a 3 story school on Goodyear Heights. About $500,000. M. M. Komarski, Central High School, Archt., Puegley, Szekley & Beam, 5716 Euclid Ave., Cleveland, Engrs.

**O., Bedford**—The Bd. Educ., A. W. Blackman, Clk., will receive bids until Jan. 15 for a 2 story, 100 x 185 ft. high school including a steam heating system. About $400,000. H. R. P. Hamilton, 1127 Guardian Bldg., Cleveland, Archts.

**O., Cleveland**—Sanlin Co., Schofield Bldg., had preliminary plans prepared for a 16 story, 86 x 165 ft. office building. About $2,000,000. Rutan, Russell & Wood, Century Bldg., Pittsburgh, Pa., Archts.

**O., Maple Heights** (Bedford P. O.)—The Bd. Educ. is having plans prepared for a 3 story addition to school including a steam heating system on Libby Road. About $300,000. C. W. Bates, Natl. Bank Bldg., Wheeling, W. Va., Archt.

**O., Ravenna**—The Bd. Educ. plans to build a 3 story school. About $300,000. O. D. Howard, 8 East Broad St., Columbus, Archt.

**O., Wauseon**—The Bd. of Trustees of Pub. Affairs will receive bids until Jan. 20 for building an earthern reservoir, auxiliary pumping station, water filtration plant and installing complete equipment. W. J. Sherman Co., Toledo, Engrs.

**Ind., Evansville**—The Evansville College will receive bids until Jan. 15 for a 3 story, 70 x 120 ft. science hall building including a steam heating system. About $250,000. Miller & Fullenwider & Dowling, 6 North Michigan Blvd., Chicago, Ill., Archts.

**Mich., Ann Arbor** — The University of Michigan, c/o M. L. Burton, Pres., plans to build 9 additional buildings including central power plant. About $5,990,000. Engineer not selected.

**Mich., Detroit**—The city plans to build an addition to the Fairview pumping station and install steam-driven centrifugal pump, coal handling equipment, etc. About $80,000. Smith, Hinchman & Grylls, 710 Washington Arcade, Engrs.

**Mich., Detroit**—The city received bids for furnishing and installing complete with equipment, 8 in. centrifugal pumps to be used in connection with relief project at Connor's Creek and Jefferson Ave., from C. McIntosh & Co., 422 Dime Bank Bldg., $65,500 and Morris Machine Wks., Baldwinsville, N. Y., $68,070.

**Ill., Chicago**—G. Bass, 6055 Euclaire Ave., plans to build a general hospital at 460 East 32d St. About $1,000,000.

**Ill., Chicago**—The Buena Memorial Presbyterian Church, 4241 Sheridan Rd., plans to build a church on Sheridan Rd. and Bway. About $250,000. I. V. Naess, 64 East Van Buren St., Archt.

**Ill., Chicago**—The Tooker Storage & Forwarding Co., 1400 South Clark St., plans to build a warehouse including a steam heating system. About $750,000.

**Ill., East St. Louis**—The East St. Louis Locomotive & Car Co., c/o R. W. Crawford, Engr., 5483 Ellis Ave., Chicago, has purchased site for a car and locomotive repair plant, here. About $1,000,000.

**Wis., Antigo**—The Bd. Educ., c/o R. A. Brandt, is having plans prepared for a 2 story, 127 x 225 ft. junior high school including a steam heating system, on Main St. About $250,000. Oppenhawer & Obel, Wausau, Archts.

**Wis., Ashland**—L. E. Myers Co., Ashland, c/o L. E. Myers, Pres., Monadnock Bldg., Chicago, Ill., plans to build dam in Flambeau River between Ladysmith and Park Falls. Installation of transmission lines also planned to serve light and power to upper state cities. About $3,000,000.

**Wis., Barron** — The Light and Water Comn. plans to build a 200-kw. water power plant. About $50,000.

**Wis., Fond du Lac**—The Bd. Educ., c/o A. M. Hunter, Secy., had plans prepared for a 3 story, 110 x 115 ft. senior high school including a steam heating system. About $275,000. Childs & Smith, 64 East Van Buren St., Chicago, Ill., Archts.

**Wis., Janesville**—The Bd. Educ., F. C. Grant, Chn. Bldg. Com., will receive bids in spring for the superstructure of a 3 story, 180 x 200 ft. high school including a steam heating system and for a 40 x 50 ft. boiler house. About $500,000. Van Ryn & De Gellike, Caswell Blk., Milwaukee, Archts. Noted Dec. 21.

**Wis., Jefferson**—The Jefferson Rubber Co. is in the market for two 150-hp. high-pressure boilers, small and large traveling crane for moulds, complete boiler room equipment and pumps. About $25,000. C. R. Girton, Mgr.

**Wis., Manitowoc** — The Common Council has passed ordinance for the installation of water mains in several streets. Pumping equipment will be required. A. H. Zander, City Hall, Consulting Engr. About $19,000.

**Wis., Manitowoc**—H. A. Kelley, 717 North 7th St., Atty., is soliciting subscriptions to raise $250,000 to build a 4 or 5 story war memorial building, including a steam heating system.

**Wis., Manitowoc**—The Manitowoc Shipbuilding Co., 16th St. and the river, will soon receive bids for a 60 x 180 ft. roundhouse and power house. About $75,000.

**Wis., Sheboygan**—The Sheboygan Cold Storage Co., c/o E. C. Peacock, South 12th St. and Jefferson Ave., plans to build a 2 and 3 story, 100 x 250 ft. cold storage plant on North Water St. Architect not selected.

**Wis., Wisconsin Veterans' Home** — The Wisconsin Veterans' Home plans to install a 10 x 14 x 16 ft. vacuum pump to accommodate 40,000 sq.ft. of radiation. W. J. Roehr, c/o the institution, Chief Engr.

**Iowa, Decorah**—City plans election Jan. 10, to vote on an additional $150,000 bonds to build a 2 or 3 story high school, including a steam heating system. About $100,000 now available. Architect not announced.

**Iowa, Dubuque**—The Howard Arney Co., Archt., 10 La Salle St., Chicago, Ill., is preparing plans for a 2 story, 75 x 100 ft. bank and office building including a steam heating system. About $250,000. Owner's name withheld.

**Minn., Fergus Falls**—Ottertail County, c/o W. Lincoln, Co. Aud., will soon receive bids for a 3 story court house including a steam heating system. About $300,000. Beuchner & Orth, 540 Shubert Bldg., St. Paul, Archts.

**Minn., Kiester**—The village plans to build a 35 to 40 hp. electric plant and are in the market for equipment. About $7,000. G. M. Olenmeyer, Recorder.

**Minn., Minneapolis**—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, plans to build a 3 or 4 story hospital including a steam heating system at the State University, here. About $400,000. C. M. Johnston, 715 Capital Bank Bldg., St. Paul, Archt.

**Minn., North Branch**—A. Nordstrom, City Clk., will receive bids until Feb. 8 for a water works system including deep well, pump and tower tank. About $40,000. Druar & Milinowski, 512 Globe Bldg., St Paul, Engrs.

**Minn., Renville**—The Bd. Educ., c/o A. R. Holmberg, Clk., will receive bids until Jan. 18, for a 2 story, 146 x 273 ft. school including a steam heating system. About $280,000. Croft & Boerner, 1006 Marquette Ave., Minneapolis, Archts. Noted Feb. 16.

**Minn., St. Paul**—The Farmers' Consolidated Distributing Co., 935 Andrus Bldg., Minneapolis, plans to build a 3 story, 75 x 125 ft. factory including a steam heating system at Prior Ave. and Montague Place, here. About $350,000. Architect not selected.

**Kan., Newton**—The city plans an election April 5 to vote on $200,000 bonds for an electric light plant. Engineer not selected.

**Ne' , Norfolk**—The Bd. Educ. will receive bids early in February for a 2 story, 145 x 208 ft. school, including a steam heating system. About $450,000. J. C. Stitt, Norfolk, Archt. Noted Nov. 30.

**Neb., Omaha**—The Home Builders, 18th and Dodge Sts., is having plans prepared for the construction of an 8 story, 70 x 132 ft. film exchange building at 18th and Davenport Sts. About $300,000. J. T. Allen, 224-26 Brandeis Theatre Bldg., Archt.

**S. D., Elk Point**—The city is having plans prepared for a sewage system including a pumping plant. About $35,000. T. H. Johnson, 319 Iowa Bldg., Sioux City, Iowa, Engr.

**N. D., Jamestown**—The Bd. Educ., N. C. Koontz, Supt., had plans prepared for a 3 story, 75 x 200 ft. high school including a steam heating system. About $250,000. Shannon, Boyd & Boyd, Jamestown, Archt. C. F. Tweed, 531 Metropolitan Bank Bldg., Minneapolis, Minn., Engr.

**Mont., Bozeman** — The Montana State College, 9th Ave., c/o A. Atkinson, Pres., plans to build college buildings. About $1,235,000.

**Mont., Miles City**—The Bd. Educ., O. Lovett, Supt. of Schools, had plans prepared for a 3 story high school including a steam heating system. About $40,000.

**Mont., Missoula**—The University of Montana plans to build a library and steam heating plant on campus. About $600,000. E. O. Sisson, Pres.

**Mo., St. Louis**—The Lowenstein Bros. Real Estate Co., Wainwright Bldg., is having plans prepared for a 4 story, 144 x 250 ft. office building. About $750,000. Widman, Walsh & Pankan, Wainwright Bldg., Archts.

**Mo., St. Louis**—F. Obear, Arcade Bldg., is interested in syndicate which plans to build a 110 x 150 ft. hotel and mercantile building on Delmar and DeBaliviere Sts. About $500,000. Architect not selected.

**Tex., Amarillo**—The Fort Worth & Denver Railway officials have authorized the expenditure of $200,000 for new power and electric light plant, improvements to shops and yards, etc. F. E. Clarity, Denver Record Bldg., Fort Worth, Vice-Pres. and Gen. Mgr.

**Tex., Bonham**—The City Council has been petitioned to order an election to vote on establishing a municipal light plant.

**Okla., Locust Grove**—The city had report prepared for an electric light plant. About $35,000. V. V. Long & Co., Oklahoma City, Engrs.

**Okla., Oklahoma City**—C. P. Needer and M. Jayne, Associate Archts., Empress Theater Bldg., have prepared preliminary plans for an American Legion Hospital including a 1,000-hp. power plant. About $2,000,000.

**Okla., Tulsa**—The Bd. Educ. rejected all bids for heating and plumbing system in the proposed 4 story high school. Noted Nov. 9.

**Okla., Vinita**—The city had plans prepared for a water works pumping station, and 1,500,000 gal. per day purification plant, 2 dams, etc. About $460,000. H. G. Olmstead & Co., Oklahoma City, Engrs.

**N. M., Albuquerque** — The First Natl. Bank Bldg. will receive bids Feb. 1 for an 8 story bank and office building including steam heating and ventilating systems. About $500,000. Trost & Trost, 1817 Mills Bldg., El Paso, Tex., Archts. and Engrs.

**Cal., Merced**—J. I. Motrovitch, Archt., 542 46th Ave., San Francisco, is preparing plans for a 5 story, 130 x 320 ft. hotel on L St. between 19th and 20th Aves. About $500,000. Owner's name withheld.

**Ont., Hamilton** — The Dept. of Educ., Toronto, plans to build a technical school here. About $600,000.

**Ont., Toronto**—The Bd. Educ., c/o W. W. Pearse, Secy.-Treas., 155 College St., plans to build 6 schools and make additions to 5 schools in the city, including steam heating systems. About $1,200,000.

**Ont., Toronto**—The Dept. Educ. will receive bids soon for building educational block. About $2,000,000. Address M. Doherty, c/o Dept. Educ.

**B. C., Kitimat** — The Kitimat Pulp & Paper Co. has made application to the Provincial Government of British Columbia for water privileges in connection with establishment of proposed pulp and paper mill at Lowe Inlet, Kitimat Arm. Plans include storage dams.

## CONTRACTS AWARDED

**R. I., Pawtucket**—The Hope Webbing Co., 1005 Main St., has awarded the contract for an addition to factory and a 1 story, 20 x 26 ft. addition to boiler house, to Central Constr. Co., Slater Trust Bldg., at $300,000. Noted Dec. 14.

**N. Y., Ossining**—L. F. Pilcher, State Archt., Capitol, Albany, has awarded the contract for a steam heating system to be installed in new building, at Sing Sing Prison, to A. B. Barr Co., 6 River St., Yonkers, $21,500. Noted Dec. 7.

**N. J., Ridgefield**—The Continental Paper Box Co., 122 Washington St., Brooklyn, has awarded the contract for a 100 x 500 ft. factory here, to Gretsch Engrg. Corp., 103 Park Ave., New York City, $250,000.

**Md., Baltimore**—St. Mary's Industrial School, Wilkens Ave., has awarded the contract for a 3 story, 65 x 166 ft. building for class rooms and dining hall to J. J. Moylan, 538 North Calvert St., about $500,000. A steam heating plant and plumbing system will be installed in same.

**Mich., Marion**—The Winterfield Light & Power Co. will build a 500-kw. power plant, spillway, etc. About $90,000. Work will be done by day labor.

**Wis., West Allis** (Milwaukee P. O.)—The Bd. Educ., G. A. German, Principal, has awarded the contract for a 3 story high school including a steam heating system to Kroening Constr. Co., 67th St. and National Ave., at $431,539.

**Wyo., Cheyenne**—The Memorial Hospital of Laramie County has awarded the contract for the Frances Warren Pershing Hospital, 50 x 100 ft., to A. Allison. About $300,000.

**Mo., Kansas City**—Keene & Simpson, Archts., 401 Reliance Bldg., have awarded the contract for a 6 story hospital on 45th St., to Long Contr. Co., 600 Rialto Bldg. About $450,000.

**Cal., San Diego**—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for refrigerating equipment here, to the York Constr. Co., 308 3d St., Los Angeles, at $50,725. Noted Nov. 23.

**N. B., St. John**—The Water Power Commission has awarded the contract for hydraulic machinery to Morgan-Smith Co., at $93,056, and for electrical machinery to the Canadian General Electric Co., 107 Park St., Peterboro, Ont., at $162,000.

**Ont., Hamilton**—The Canadian Libbey-Owens Sheet Glass Co., Ltd., has awarded the contract for a 150 x 540 ft. sheet glass plant to H. W. Cooper. About $1,000,000.

# PRICES - MATERIALS - SUPPLIES

**Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.**

## POWER-PLANT SUPPLIES

**HOSE**

| | Fire | 50-Ft. Lengths |
|---|---|---|
| Underwriters' 2½-in. | | 75c. per ft. |
| Common, 2½-in. | | 40% |

| | Air | | |
|---|---|---|---|
| | First Grade | Second Grade | Third Grade |
| ¾-in. per ft. | $0.50 | $0.35 | $0.25 |

Steam—Discounts from List

First grade 30% Second grade 45% Third grade 50-10%

**RUBBER BELTING**—The following discounts from list apply to transmission rubber and duck belting:

| | | | |
|---|---|---|---|
| Competition | 60% | Best grade | 35% |
| Standard | 50% | | |

**LEATHER BELTING**—Present discounts from list in fair quantities (½ doz. rolls):

| Light Grade | Medium Grade | Heavy Grade |
|---|---|---|
| 30% | 25% | 20% |

**RAWHIDE LACING** { For cut, best grade, 25%, 2nd grade, 30%. For laces in sides, best, 79c per sq. ft.; 2nd, 75c. Semi-tanned: cut, 20%; sides, 83c per sq. ft.

**PACKING**—Prices per pound:

| | |
|---|---|
| Rubber and duck for low-pressure steam | $1.00 |
| Asbestos for high-pressure steam | 2.00 |
| Duck and rubber for piston packing | 1.20 |
| Flax, regular | 1.20 |
| Flax, waterproofed | 1.70 |
| Compressed asbestos sheet | 1.00 |
| Wire insertion asbestos sheet | 1.50 |
| Rubber sheet | .50 |
| Rubber sheet, wire insertion | .70 |
| Rubber sheet, duck insertion | .60 |
| Rubber sheet, cloth insertion | .30 |
| Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes | 1.50 |
| Asbestos wick, ½- and 1-lb. balls | .85 |

**PIPE AND BOILER COVERING**—Below are part of standard lists, with discounts.

| PIPE COVERING | | BLOCKS AND SHEETS | |
|---|---|---|---|
| Pipe Size | Standard List Per Lin.Ft. | Thickness | Price per Sq.Ft. |
| 1-in. | $0.27 | ½-in. | $0.27 |
| 2-in. | .36 | 1 -in. | .30 |
| 6-in. | .80 | 1½-in. | .45 |
| 4-in. | .60 | 2 -in. | .60 |
| 3-in. | .45 | 2½-in. | .75 |
| 8-in. | 1.10 | 3 -in. | .90 |
| 10-in. | 1.30 | 3½-in. | 1.05 |

85% magnesia high pressure ..... List +5%

For low-pressure heating and return lines { 4-ply ..... 50% off; 3-ply ..... 52% off; 2-ply ..... 54% off.

**PORTLAND CEMENT**—New York, $3.80 without bags, in cargo lots delivered on job.

**STRUCTURAL STEEL**—New York warehouse price, 3 to 15-in. beams and channels and 3 to 6-in. angles and tees; all $3.80 per 100 lb.; plates, $4.

**COTTON WASTE**—The following prices are in cents per pound:

| | New York | | | |
|---|---|---|---|---|
| | Current | One Year Ago | Cleveland | Chicago |
| White | 13.00@15.00 | 13.00 | 15.00 | 15.00@17.00 |
| Colored mixed | 7.00@12.00 | 9.00 to 12.00 | 11.00 | 11.00@13.00 |

**WIPING CLOTHS**—Jobbers' price per 1000 is as follows:

| | 13½ x 13½ | 13½ x 20½ |
|---|---|---|
| Cleveland | $55.00 | $65.00 |
| Chicago | 41.00 | 43.50 |

**LINSEED OIL**—These prices are per gallon:

| | New York | | Chicago | |
|---|---|---|---|---|
| | Current | One Year Ago | Current | One Year Ago |
| Raw in barrels (5 bbl. lots) | $0.90 | $2.15 | $1.01 | $2.37 |
| 5-gal. cans | 1.05 | 2.30 | 1.26 | 2.57 |

With lower prices obtainable in New York.

**WHITE AND RED LEAD**—Base price per pound:

| | Red | | | | White | | | |
|---|---|---|---|---|---|---|---|---|
| | Current | | 1 Year Ago | | Current | | 1 Yr. Ago | |
| | Dry | In Oil | Dry | In Oil | Dry and In Oil | | Dry and In Oil | |
| 100-lb. keg | 14.00 | 15.50 | 13.00 | 14.50 | 14.00 | | 13.00 | |
| 25- and 50-lb. kegs | 14.25 | 15.75 | 13.25 | 14.75 | 14.25 | | 13.25 | |
| 12½-lb. keg | 14.50 | 16.00 | 13.50 | 15.00 | 14.50 | | 13.50 | |
| 1-lb. cans | 17.00 | 18.50 | 15.00 | 16.50 | 17.00 | | 15.00 | |
| 5-lb. cans | 19.00 | 20.50 | 16.00 | 17.50 | 19.00 | | 16.00 | |

500 lb. lots less 10% discount; 2000 lb. lots less 10-2½%.

**RIVETS**—The following quotations are allowed for fair-sized orders from warehouse:

| | New York | Cleveland | Chicago |
|---|---|---|---|
| Steel ½ and smaller | 20% | 50% | 30% |
| Tinned | 20% | 50% | 30% |

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York $6.00 Chicago $5.83 Pittsburgh $4.60

Structural rivets, same sizes:

New York $5.75 Chicago $5.73 Pittsburgh $4.50

**REFRACTORIES**—Prices in carlots:

| | | |
|---|---|---|
| Bauxite brick, 56% alumina, f.o.b. Pittsburgh | per 1000 | $160 |
| Chrome brick, eastern Shipping points | net ton | 100@$110 |
| Chrome cement, 40@45% $Cr_2O_3$ | net ton | 55@ 60 |
| Chrome cement, 40@45% $Cr_2O_3$, in sacks | net ton | 60@ 65 |
| Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky | per 1000 | 55@ 60 |
| Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky | per 1000 | 45@ 50 |
| Magnesite brick: 9-in. straight | net ton | 110 |
| Magnesite brick: 9-in. arches, wedges and keys | net ton | 121 |
| Magnesite brick: Soaps and splits | net ton | 134 |
| Silica brick: Chicago district | per 1000 | 65@ 70 |
| Silica brick: Birmingham, Ala. | per 1000 | 56@ 61 |
| Silica brick: Mt. Union, Pa. | per 1000 | 55@ 60 |

**BABBITT METAL**—Warehouse prices in cents per pound:

| | New York | | Cleveland | | Chicago | |
|---|---|---|---|---|---|---|
| | Current | One Year Ago | Current | One Year Ago | Current | One Year Ago |
| Best grade | 70.00 | 90.00 | 44.00 | 70.00 | 43.00 | 60.00 |
| Commercial | 30.00 | 50.50 | 16.50 | 16.50 | 11.00 | 13.00 |

**COLD FINISHED STEEL**—Warehouse prices are as follows:

| | New York | Chicago | Cleveland |
|---|---|---|---|
| Round shafting or screw stock, per 100 lb. base | $5.50 | $5.80 | $4.84 |
| Flats, square and hexagons, per 100 lb. base | 6.00 | 6.30 | 5.34 |

**SHEETS**—Quotations are in cents per pound in various cities from warehouse; also the base quotations from mill:

| | Large Mill Lots | New York | | | |
|---|---|---|---|---|---|
| Blue Annealed | Pittsburgh | Current | One Year Ago | Cleveland | Chicago |
| No. 10 | 3.55 | 5.20 | 4.57 | 5.00 | 6.13 |
| No. 12 | 3.60 | 5.25 | 4.62 | 5.05 | 6.18 |
| No. 14 | 3.65 | 5.30 | 4.67 | 5.10 | 6.23 |
| No. 16 | 3.75 | 5.40 | 4.77 | 5.20 | 6.33 |
| Black | | | | | |
| Nos. 18 and 20 | 4.20 | 6.30 | 5.30 | 5.60 | 6.90 |
| Nos. 22 and 24 | 4.25 | 6.35 | 5.35 | 5.75 | 6.95 |
| No. 26 | 4.30 | 6.40 | 5.40 | 5.80 | 7.00 |
| No. 28 | 4.35 | 6.50 | 5.50 | 5.90 | 7.10 |
| Galvanized | | | | | |
| No. 10 | 4.70 | 7.05 | 5.75 | 6.25 | 7.25 |
| No. 12 | 4.80 | 7.15 | 5.85 | 6.35 | 7.30 |
| No. 14 | 4.80 | 7.15 | 5.85 | 6.35 | 7.45 |
| Nos. 18 and 20 | 5.10 | 7.40 | 6.15 | 6.65 | 7.75 |
| Nos. 22 and 24 | 5.25 | 7.55 | 6.30 | 6.80 | 8.15 |
| No. 26 | 5.40 | 7.70 | 6.45 | 6.95 | 8.30 |
| No. 28 | 5.70 | 8.00 | 6.75 | 7.25 | 8.60 |

**WROUGHT PIPE**—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

| Steel | | | Iron | | |
|---|---|---|---|---|---|
| Inches | Black | Galv. | Inches | Black | Galv. |
| ¼ to 3 | 54 to 57½ | 41½ to 44 | ⅛ | 15½ to 25½ | +1½ to 11 |
| | | | ¼ | 19½ to 29½ | 1½ to 11½ |
| | | | ⅜ to 1¼ | 24½ to 34½ | 8 to 18½ |

LAP WELD

| | | | | | |
|---|---|---|---|---|---|
| 2 | 47 to 50½ | 34½ to 38 | 2 | 20½ to 28½ | 6½ to 14½ |
| 2½ to 6 | 50 to 53½ | 37½ to 41 | 2½ to 6 | 22½ to 30½ | 9½ to 17½ |
| 7 to 12 | 47 to 50½ | 33½ to 37 | 7 to 12 | 19½ to 27½ | 6½ to 14½ |
| 13 and 14 | 37½ to 41 | | | | |
| 15 | 35 to 38½ | | | | |

BUTT WELD, EXTRA STRONG, PLAIN ENDS

| | | | | | |
|---|---|---|---|---|---|
| ¼ to 1½ | 52 to 55½ | 39½ to 43 | ¼ to 1½ | 24½ to 34½ | 9½ to 19½ |
| 2 to 3 | 53 to 56½ | 40½ to 44 | | | |

LAP WELD, EXTRA STRONG, PLAIN ENDS

| | | | | | |
|---|---|---|---|---|---|
| 2 | 45 to 48½ | 33½ to 37 | 2 | 21½ to 29½ | 8½ to 16½ |
| 2½ to 4 | 48 to 51½ | 36½ to 40 | 2½ to 4 | 23½ to 31½ | 11½ to 19½ |
| 4½ to 6 | 47 to 50½ | 35½ to 39 | 4½ to 6 | 22½ to 30½ | 10½ to 18½ |
| 7 to 8 | 43 to 46½ | 29½ to 33 | 7 to 8 | 14½ to 22½ | 2½ to 10½ |
| 9 to 12 | 38 to 41½ | 24½ to 28 | 9 to 12 | 9½ to 17½ | 5½ to+2½ |

**BOILER TUBES**—The following are the prices for carload lots, f.o.b. Pittsburgh:

| Lap Welded Steel | | Charcoal Iron | |
|---|---|---|---|
| 3½ to 4½ in. | 20 to 40½ | 1½ to 1¾ in. | +23 |
| 2½ to 3¼ in. | 11 to 30½ | 2¼ in. | +10 to +12 |
| 2¼ to 2½ in. | 3 to 30½ | 2½ in. | +1 to +10 |
| 1¾ to 1¼ in. | +7 to—19½ | 2¾ and 3¼ in. | —1½ to +3 |
| | | 3½, 4 and 4½ in. | —8 |

Standard Commercial Seamless — Cold Drawn or Hot Rolled

| | Per Net Ton | | Per Net Ton |
|---|---|---|---|
| 1 in. | $327 | 1¼ in. | $207 |
| 1¼ in. | 267 | 2 to 2½ in. | 177 |
| 2½ in. | 257 | 2¾ to 3½ in. | 167 |
| 1½ in. | 207 | 4 in. | 187 |
| | | 4½ to 5 in. | 207 |

## ELECTRICAL SUPPLIES

**ARMORED CABLE**—

| B. & S. Size | Two Cond. M Ft. | Three Cond. M Ft. | Two Cond. Lead M Ft. | Three Cond. Lead M Ft. |
|---|---|---|---|---|
| No. 14 solid | $ 85.00(net) | $138.00 | $164.00 | $210.00 |
| No. 12 solid | 135.00 | 170.00 | 225.00 | 265.00 |
| No. 10 solid | 185.00 | 235.00 | 275.00 | 325.00 |
| No. 8 stranded | 285.00 | 375.00 | 520.00 | 500.00 |
| No. 6 stranded | 400.00 | 500.00 | 560.00 | ..... |

From the above lists discounts are:

| | | | |
|---|---|---|---|
| Less than coil lots | + 5% | | +15% |
| Coils to 1,000 ft. | — 5% | | List Net |
| 1,000 ft. and over | —10% | | 7% |

**BATTERIES, DRY**—Regular No. 6 size red seal, Columbia, or Ever-Ready:

| | Each, Net |
|---|---|
| Less than 12 | $0.48 |
| 12 to 50 | .41 |
| 50 to 125 (bbl.) | .38 |
| 125 (bbl.) or over | .35 |

**CONDUIT**, Price per 1000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

| | Conduit | | Elbows | | Couplings | |
|---|---|---|---|---|---|---|
| Size, In. | Black 2,500 to 5,000 Lbs. | Galvanized 2,500 to 5,000 Lbs. | Black 2,500 to 5,000 Lbs. | Galvanized 2,500 to 5,000 Lbs. | Black 2,500 to 5,000 Lbs. | Galvanized 2,500 to 5,000 Lbs. |
| ¼ | 85.66 | 90.39 | 20.20 | 21.34 | 6.38 | 6.74 |
| ⅜ | 113.62 | 119.99 | 26.58 | 27.83 | 7.44 | 7.86 |
| 1 | 167.96 | 177.38 | 39.35 | 41.56 | 10.63 | 11.23 |
| 1¼ | 227.24 | 239.98 | 50.10 | 52.80 | 13.82 | 14.60 |
| 1½ | 271.70 | 286.93 | 66.80 | 70.40 | 18.93 | 19.95 |
| 2 | 365.56 | 386.06 | 122.47 | 129.07 | 23.38 | 24.64 |
| 2½ | 577.98 | 610.39 | 200.41 | 211.21 | 31.18 | 32.85 |
| 3 | 755.82 | 798.20 | 534.43 | 563.23 | 44.53 | 46.94 |
| 3½ | 936.38 | 987.52 | 1,180.20 | 1,243.80 | 66.80 | 70.40 |
| 4 | 1,131.20 | 1,191.81 | 1,363.91 | 1,437.41 | 89.07 | 93.87 |

**CONDUIT NON-METALLIC, LOOM**—

| Size I. D., In. | Feet per Coil | List, Ft. | |
|---|---|---|---|
| ⅜ | 250 | $0.05½ | |
| ½ | 250 | .06 | |
| ¾ | 250 | .09 | |
| 1 | 200 | .12 | 1000 ft. and |
| 1¼ | 200 | .15 | over.... 40% |
| 1½ | 150 | .18 | Coils.....30% |
| 1 | 100 | .25 | Less coils, 20% |
| 1¼ | 100 | .33 | |
| 1½ | Odd lengths | .40 | |
| 2 | Odd lengths | .55 | |

**CUT-OUTS**—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

| | | | |
|---|---|---|---|
| S. P. M. L. | $0.12 | D. P. D. B. | $0.43 |
| D. P. M. L. | .21 | T. P. to D. P. S. B. | .26 |
| T. P. M. L. | .33 | T. P. S. B. | .38 |
| D. P. S. B. | .23 | T. P. D. B. | .64 |

CUT-OUTS, N. E. C. FUSE

| | 0-30 Amp. | 31-60 Amp. | 60-100 Amp. |
|---|---|---|---|
| D. P. M. L. | $0.50 | $1.30 | $1.68 |
| T. P. M. L. | .70 | 1.70 | 2.40 |
| D. P. S. B. | .63 | 1.60 | ..... |
| T. P. S. B. | 1.15 | 2.40 | ..... |
| D. P. D. B. | 1.10 | 3.00 | ..... |
| T. P. D. B. | 1.90 | 5.40 | ..... |
| T. P. to D. P. D. B. | 1.30 | 3.80 | ..... |

**FLEXIBLE CORD**—Price per 1,000 ft. in coils of 250 ft.:

| | |
|---|---|
| No. 18 cotton twisted | $23.50 |
| No. 16 cotton twisted | 27.00 |
| No. 18 cotton parallel | 29.40 |
| No. 16 cotton parallel | 36.25 |
| No. 18 cotton reinforced heavy | 39.50 |
| No. 16 cotton reinforced heavy | 45.75 |
| No. 18 cotton reinforced light | 34.80 |
| No. 16 cotton reinforced light | 39.45 |
| No. 18 cotton Canvasite cord | 26.00 |
| No. 16 cotton Canvasite cord | 28.50 |

**FUSES, ENCLOSED**—

| 250-Volt | Std. Pkg. | List |
|---|---|---|
| 3-amp. to 30-amp. | 100 | $0.25 |
| 35-amp. to 60-amp. | 100 | .35 |
| 65-amp. to 100-amp. | 50 | .90 |
| 110-amp. to 200-amp. | 25 | 2.00 |
| 225-amp. to 400-amp. | 25 | 3.60 |
| 425-amp. to 600-amp. | 10 | 5.50 |

| 600-Volt | Std. Pkg. | List |
|---|---|---|
| 3-amp. to 30-amp. | 100 | $0.40 |
| 35-amp. to 60-amp. | 100 | .60 |
| 65-amp. to 100-amp. | 50 | 1.50 |
| 110-amp. to 200-amp. | 25 | 2.50 |
| 225-amp. to 400-amp. | 25 | 5.50 |
| 450-amp. to 600-amp. | 10 | 8.00 |

Discount: Less 1-5th standard package 15%
1-5th to standard package 28%
Standard package 45%

**FUSE PLUGS, MICA CAP**—

| | |
|---|---|
| 0-30 ampere, standard package | $5.25C |
| 0-30 ampere, less than standard package | 6.00C |

**LAMPS**—Below are present quotations in less than standard package quantities:

| Straight-Side Bulbs — Mazda B— | | | | Pear-Shaped Bulbs — Mazda C— | | | |
|---|---|---|---|---|---|---|---|
| Watts | Plain | Frosted | No. in Package | Watts | Clear | Frosted | No. in Package |
| 10 | $0.40 | $0.45 | 100 | 75 | $0.75 | $0.80 | 50 |
| 15 | .40 | .45 | 100 | 100 | 1.10 | 1.25 | 24 |
| 25 | .40 | .45 | 100 | 150 | 1.55 | 1.70 | 24 |
| 40 | .40 | .45 | 100 | 200 | 2.10 | 2.30 | 24 |
| 50 | .40 | .45 | 100 | 300 | 3.15 | 3.40 | 24 |
| 60 | .45 | .50 | 100 | | | | 12 |
| | | | | 500 | 4.60 | 4.90 | 12 |
| | | | | 750 | 6.50 | 6.90 | 8 |
| | | | | 1,000 | 7.50 | 7.95 | 8 |

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

**PLUGS, ATTACHMENT**—

| | Each |
|---|---|
| Porcelain separable attachment plug | $0.28 |
| Composition 2-piece attachment plug | .36 |
| Swivel attachment plug | .20 |
| Current taps | .45 |

**RUBBER-COVERED COPPER WIRE**—Per 1000 ft. f. o. b. New York.

| No. | Solid Single Braid | Solid Double Braid | Stranded, Double Braid | Duplex |
|---|---|---|---|---|
| 14 | $ 9.00 | $12.50 | $16.28 | $25.50 |
| 12 | 13.70 | 17.48 | 19.79 | 31.00 |
| 10 | 17.90 | 22.01 | 26.06 | 42.00 |
| 8 | 22.50 | 31.05 | 35.00 | 57.00 |
| 6 | ..... | ..... | 49.00 | ..... |
| 4 | ..... | ..... | 68.00 | ..... |
| 2 | ..... | ..... | 95.45 | ..... |
| 1 | ..... | ..... | 140.00 | ..... |
| 0 | ..... | ..... | 158.00 | ..... |
| 00 | ..... | ..... | 185.50 | ..... |
| 000 | ..... | ..... | 228.00 | ..... |
| 0000 | ..... | ..... | 283.00 | ..... |

**Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:**

| | Denver | | | Birmingham | | |
|---|---|---|---|---|---|---|
| No. | Single Braid | Double Braid | Duplex | Single Braid | Double Braid | Duplex |
| 14 | $13.50 | $16.80 | $30.80 | $10.81* | $13.50 | $28.90 |
| 10 | 21.10 | 24.60 | 51.55 | 19.02* | 24.05 | 49.43 |
| 8 | 27.60 | 32.35 | 67.60 | 27.84* | 33.84 | 63.49 |
| 6 | 49.00 | 51.30 | ..... | 50.00* | ..... | ..... |
| 4 | 66.00 | 68.85 | ..... | 89.60† | ..... | ..... |
| 2 | 93.50 | 95.50 | ..... | 1.8.00 | ..... | ..... |
| 1 | 128.00 | 131.05 | ..... | 156.00 | ..... | ..... |
| 0 | 175.00 | 175.00 | ..... | 194.00 | ..... | ..... |
| 00 | ..... | ..... | ..... | 225.15 | ..... | ..... |
| 000 | ..... | ..... | ..... | 256.00 | ..... | ..... |
| 0000 | ..... | ..... | ..... | 325.00 | ..... | ..... |

* Solid; † stranded.

**SOCKETS, BRASS SHELL**—

| ½ In. or Pendant Cap | | | ¾ In. Cap | | |
|---|---|---|---|---|---|
| Key Each | Keyless Each | Pull Each | Key Each | Keyless Each | Pull Each |
| $0.33 | $0.30 | $0.60 | $0.39 | $0.36 | $0.66 |

| | |
|---|---|
| Less 1-5th standard package | +50% |
| 1-5th to standard package | +20% |
| Standard package | —15% |

**WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE**—

| | |
|---|---|
| No. 18 B. & S. regular spools (approx. 8 lb.) | 50c. lb |
| No. 18 B. & S. regular 1-lb. coils | 51c. lb |

**WIRING SUPPLIES**—

| | |
|---|---|
| Friction tape, ¾ in., less 100 lb. 56c. lb., 100 lb. lots | 52c. lb |
| Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots | 60c. lb |
| Wire solder, less 100 lb. 47c. lb., 100 lb. lots | 42c. lb |
| Soldering paste, 2 oz. cans | $1.50 doz |

**SWITCHES, KNIFE**—

TYPE "C" NOT FUSIBLE

| Size, Amp. | Single Pole, Each | Double Pole, Each | Three Pole, Each | Four Pole, Each |
|---|---|---|---|---|
| 30 | $0.42 | $0.68 | $1.02 | $1.36 |
| 60 | .74 | 1.22 | 1.84 | 2.44 |
| 100 | 1.50 | 2.50 | 3.76 | 5.00 |
| 200 | 2.70 | 4.50 | 6.76 | 9.00 |

TYPE "C" FUSIBLE, TOP OR BOTTOM

| | | | | |
|---|---|---|---|---|
| 30 | 70 | 1.06 | 1.60 | 2.12 |
| 60 | 1.18 | 1.80 | 2.70 | 3.60 |
| 100 | 2.38 | 3.66 | 5.50 | 7.30 |
| 200 | 4.40 | 6.76 | 10.14 | 13.50 |

Discounts:

| | |
|---|---|
| Less than $10.00 list value | +25% |
| $10 to $25 list value | +10% |
| $25 to $50 list value | + 5% |
| $50 to $200 list value | —10% |
| $200 list value or over | —15% |